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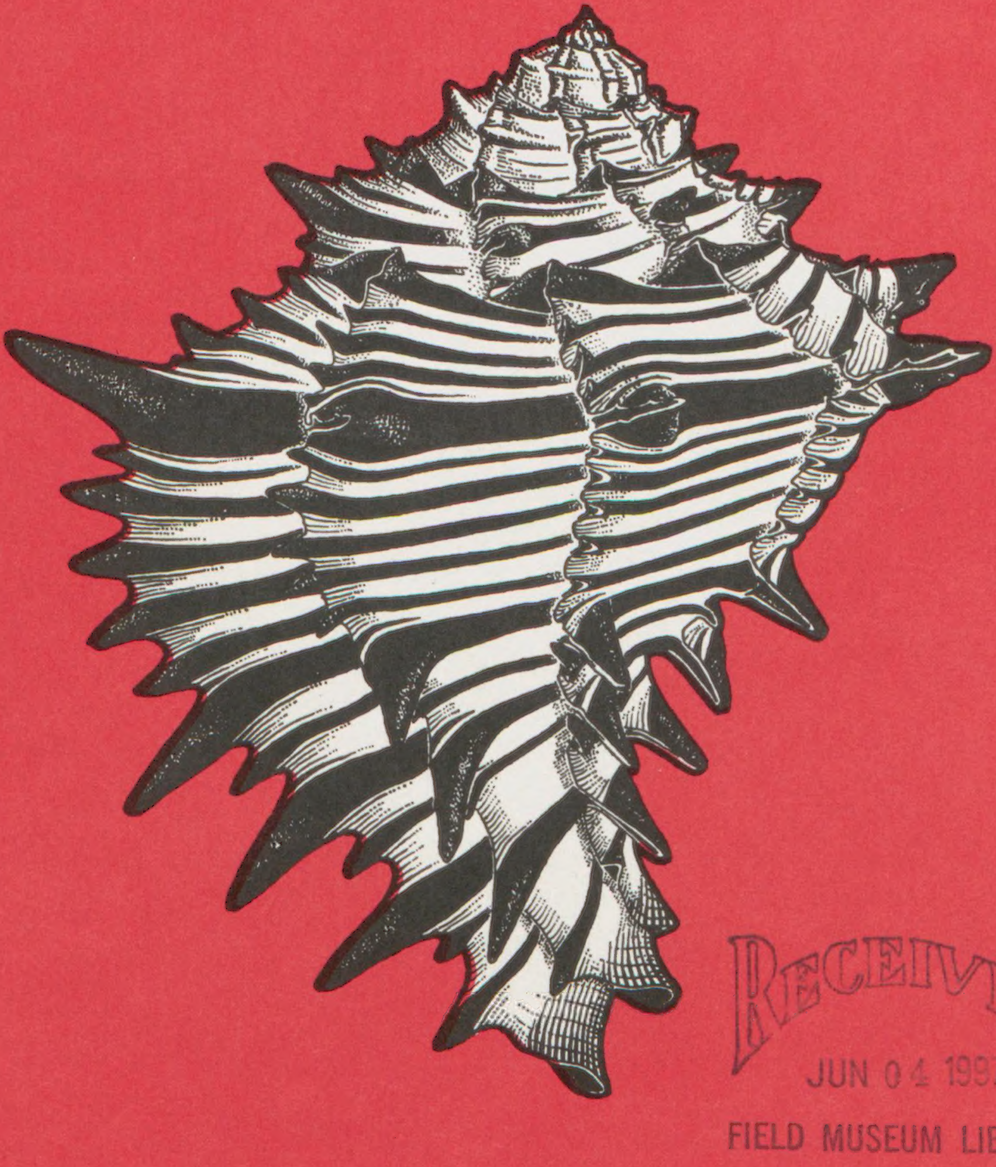

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CANDIDULA ULTIMA (MOUSSON, 1872) (MOLLUSCA, PULMONATA, HYGROMIIDAE), A NICE CASE OF ADAPTIVE CONVERGENCE[1]

M. R. Alonso, M. Ibánez and F. C. Henríquez[2]

Abstract: *Leucochroa ultima* Mousson (recent), *L. pressa* Mousson (recent) and *L. accola Mousson* (subfossil) are three nominal taxa of the Canarian island of Fuerteventura, traditionally referred to the family Sphincterochilidae due to shell characteristics and way of life. Our investigation showed that they really belong to the hygromiid genus *Candidula*, being a nice example of convergent adaptation with the Sphincterochilidae. It is the southernmost known case of autochthonous presence of the genus, which arrived from the mainland of Africa likely posteriorly to the last glaciation, between 30–50 thousand years ago. Lectotypes of *L. ultima*, *L. pressa* and *L. accola* are designated and figured. *L. pressa* and *L. accola* are treated as junior synonyms of *L. ultima*.

Key words: Canary Islands, *Candidula*, Hygromiidae, adaptive convergence, Sphincterochilidae.

INTRODUCTION

More than 120 yeas ago, Mousson (1872) described three taxa from Fuerteventura (Canary Islands) as belonging to the genus *Leucochroa* von Martens, 1860 [non Beck, 1837]. Mousson indicated that the first, *L. ultima*, is similar to *Helix cariosa* Olivier, 1804 (= *Sphincterochila cariosa*), from Palestine. He also indicated that the second taxon, *L. pressa*, possibly could be an individual variation of *L. ultima* and the third, *L. accola*, a smallest copy of both. Wollaston (1878) suggested that only two species (*L. ultima* and *L. Accola*) are in reality represented by the three forms and this opinion has been subsequently followed (Zilch, 1966; Richardson, 1980). As these taxa remained unknown anatomically. Zilch (1966) classified them due to conchological criteria in the genus *Sphincterochila* Ancey, 1887.

Studying its anatomy, we could verify that these taxa don't have any relation with the family Sphincterochilidae and represent a single species only. This paper details the anatomical and morphological findings and discusses its relationships.

METHODS

The conchological measurements (Table 1) were taken using a Silvac electronic caliper, from shells originating from nine different sites of all the distribution area of *L. ultima* as well as from type material of *L. accola*. Furthermore, we have calculated some indices, that inform about the relation between the measurements; B/A relates the shell diameter to its height; C/A indicates the importance of the last whorl in the shell height; D/E relates the length and

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TABLE 1.

Biometric data (dimensions in mm) and indices of the shell. A: shell height; B: shell diameter; C. last whorl height; D: aperture length; E: aperture width; F: umbilicus diameter; G: aperture area (in mm^2) [assumptive as a circle: $(D+E)^2/16\pi$]; n: number of measured specimens. Values: M, maximum; m, minimum; X, average; CV: Pearson's variation coefficient (in %). **1)**: *Candidula ultima* (including type material of *L. accola*); **2)**: *Leucochroa accola* type material (ZMZ 502774 and 502773).

	A	B	C	D	E	F	G	B/A	C/A	D/E	B/F	n
1)												
M	10·68	16·04	8·48	6·95	7·63	3·98	41·74	1·75	0·89	1·10	6·07	
m	5·90	7·80	4·10	3·00	3·50	1·40	8·30	1·13	0·69	0·83	3·61	
X	8·03	11·64	6·33	5·14	5·31	2·54	22·14	1·45	0·79	0·97	4·67	66
CV	12·22	13·47	13·35	15·63	14·84	18·86	29·97	6·67	3·94	4·88	7·80	
2)												
M	7·50	9·80	5·70	3·90	4·20	2·20	12·57	1·59	0·78	0·95	6·07	
m	5·90	8·50	4·10	3·40	3·80	1·40	10·75	1·13	0·69	0·83	4·45	
X	6·78	9·15	5·02	3·65	4·02	1·78	11·55	1·36	0·74	0·91	5·21	6
CV	8·11	5·28	10·30	4·11	2·21	12·15	4·61	7·61	3·97	4·97	8·99	

width of the aperture, showing its rounded/ovate degree; and B/F compares the shell diameter to the umbilicus diameter. Moreover, it is possible to calculate with a small error the aperture area (G) using the parameters D and E in nearly circular apertures (as those of *L. ultima*, with D/E ≈ 1). The relations between the parameters A–B and B–G, respectively, are also shown in Fig. 10.

The map of distribution has been produced with the computing method of La-Roche & Barquín (1993) and the informatic programs Surfer and MapViewer (Golden Software, Inc). The terms "proximal" and "distal" refer to the position in relation to the genital orifice. Measurement of shell whorl number follows Kerney & Cameron (1979: 13).

SYSTEMATIC DESCRIPTIONS

Hygromiidae Tryon, 1866

Candidula Kobelt, 1871

Candidula ultima (Mousson, 1872) n. comb.

syn. *Leucochroa pressa* Mousson, 1872
n. syn. *Leucochroa accola* Mousson, 1872

Leucochroa ultima Mousson, 1872: 19–20, pl. 1 fig. 34–36 [loc. typ.: Fuerteventura]; Pfeiffer, 1872–1876: 57–58, pl. 119 fig. 34–36; 1876: 193; Wollaston, 1878: 324–325; Mabille, 1884: 231; Tryon, 1887: 14, pl. 2 figs. 60–62; Pilsbry, 1895: 234; Gude, 1896: 18; Odhner, 1931: 104.

Leucochroa pressa Mousson, 1872: 20, pl. 1 fig. 37–39 [loc. typ.: Fuerteventura]; Pfeiffer, 1872–1876: 58, pl. 119 fig. 37–39; 1876: 194; Wollaston, 1878: 325; Mabille, 1884: 231; Tryon, 1887: 14, pl. 2 figs. 63–65; Pilsbry, 1895: 234; Gude, 1896: 18.

Leucochroa accola Mousson, 1872: 20–21, pl. 1 fig. 40, 41 [loc. typ.: Fuerteventura]; Pfeiffer, 1872–1876: Nov. Conch., 4: 58–59, pl. 119 fig. 40–41; 1876: 200; Wollaston, 1878: 325–326; Mabille, 1884: 230–231; Tryon, 1887: 14, pl. 2 figs. 66–67; Pilsbry, 1895: 234; Gude, 1896: 18; Groh, 1985: 96.

Sphincterochila ultima, – Zilch, 1966: 99; Richardson, 1980: 515–516.

Sphincterochila accola, – Zilch, 1966: 89; Richardson, 1980: 506.

Type material examined (all collected by K. von Fritsch): Lectotype (here designated) and 2 paralectotypes of *Leucochroa ultima* Mousson, 1872 (Zoologisches Museum der Universität, Zürich: ZMZ 502763/3) and other 20 paralectotypes (Natur-Museum Senckenberg, Frankfurt/Main: SMF 7722/20). Lectotype (here designated) and a paralectotype of *Leucochroa pressa* Mousson, 1872 (ZMZ 502764/2) and other 2 paralectotypes (SMF 7723/2). Lectotype (here designated) and 3 paralectotypes of *Leucochroa accola* Mousson, 1872 (ZMZ 502774) and other 5 paralectotypes (ZMZ 502773/2 and SMF 7721/3).

Our material was collected between February 1980 and April 1995, in several localities of the island (Fig. 1). *L. accola* was collected subfossil, from three localities of the "Jable", a great dune extension (± 30 km^2) of the isthmus of the Jandia peninsula, in the South of the island), between 50–100 m altitude.

Distribution and habitat: C. ultima is a xeroresistant species, endemic to Fuerteventura and well adapted to desert – subdesert climate (annual rainfall <100–200 mm, subordinated to the altitude); it occurs between 50–400 m altitude, in a dry and temperate to warm habitat, generally of stony ground; the dryness is accentuated by the desiccative effect of the wind, nearly constant every year. The specimens, as well as in the Sphincterochilidae species, are scattered at midday on the ground without any special sun protection. It is the southernmost known case of autochthonous presence of the genus. Its present distribution area is minor than that of the ancient times, with a small southern population isolated from the main population by the "Jable".

Description: Body uniform pale-brown. Shell (Figs. 2–4; Table 1) solid, usually with a domed spire, an angular to keeled periphery and 5–6 flattened whorls. Suture shallow in the first whorls and frequently deep in the most expanded last whorl. Umbilicus roundish and deep. Aperture oblique, roundish to ovate, slightly angulated in the palatal side and lacking internal rib. Peristome not thickened, slightly reflexed at its columellar margin. Protoconch ranging from white to light brown or bluish; it is smooth with few faint growth lines near its end. Beginning of teleoconch also with small coloured blotches and the remainder of an uniform white chalky colour. Teleoconch surface with irregularly undulated ribs in the first whorls; last two whorls with discontinuous ribs, giving a softly granulated look.

Mantle collar without features which distinguish it from those of other Hygromiidae. Pallial region extended over approximately the last two thirds of the last whorl. Heart of about half the length of the kidney, which is somewhat longer than half the length of the lung roof. Secundary urether very short: It opens approximately in the junction with the primary urether and continues as an open groove bordered by the hind gut at one side and a low but conspicuously erect margin at the other side.

Jaw odontognathous, pale-brown, translucent, softly ribbed and devoid of central denticle. Radula (Figs. 5–8) consisting of many rows of teeth each according to formula 29–30 + C + 29–30. Central tooth wide, without ectocones and with wide basal plate and raised pointed upper vertices. First lateral teeth having wide basal plate but with inner vertex missing; body with large pointed mesocone and small pointed ectocone. At about ninth or tenth lateral tooth, inner side of mesocone showing slight protuberance developing into pointed cusp in following lateral and marginal teeth. Last marginal teeth smaller, having mesocone and ectocone with two blunt cusps.

Genitalia (Fig. 9): Eight specimens have been studied anatomically. The right ommatophore retractor muscle runs free, i.e. not crossing between penis and vagina. Penial nerve arising in the pedal ganglion. Hermaphrodite duct without accessory seminal vesicles.

Genital atrium very short. Tubular penis approximately half as long as the epiphallus and slightly broadened over most of its length, corresponding with the presence of the penial papilla inside. Flagellum of similar length than penis and more slender than epiphallus. Retractor muscle with epiphallar insertion (close to its proximal end) and similar length than epiphallus. Penis and proximal epiphallus enveloped by a very thin sheath. Epiphallus lumen with three longitudinal ridges while the penial lumen is smooth. An also smooth penial papilla is present, almost as long as the penis; it is cylindrical, with a pointed apex and

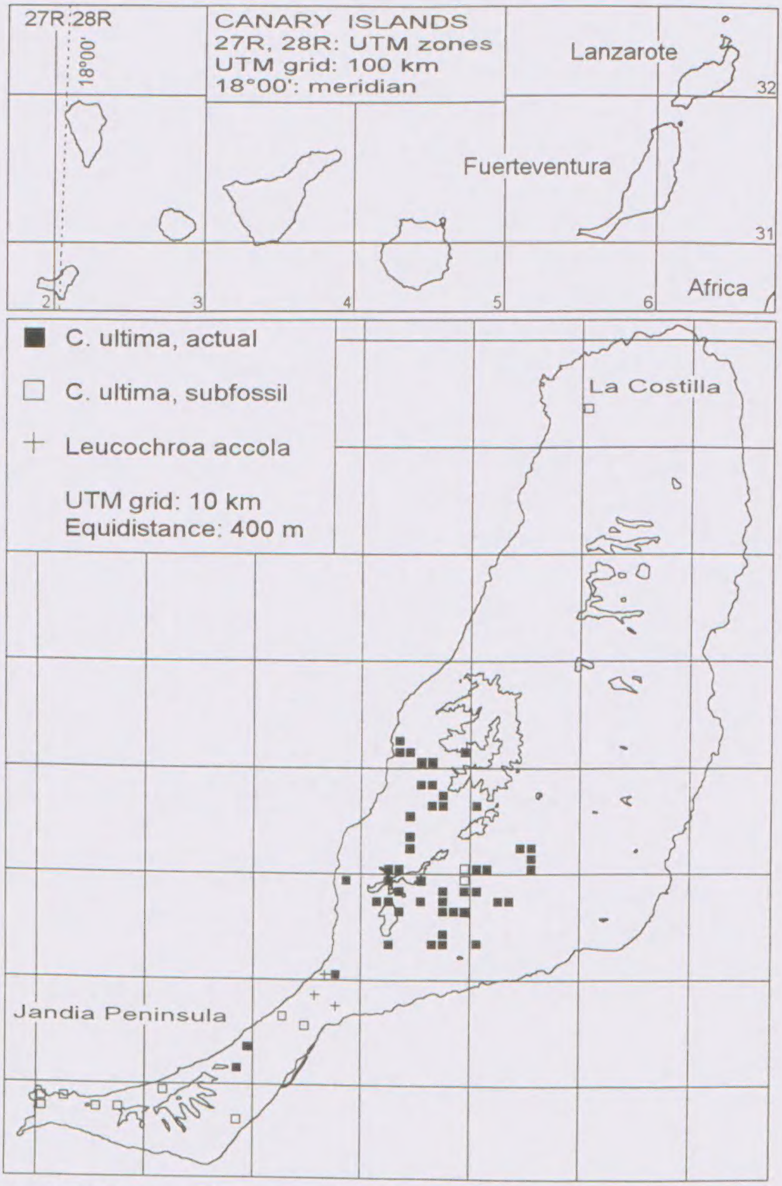
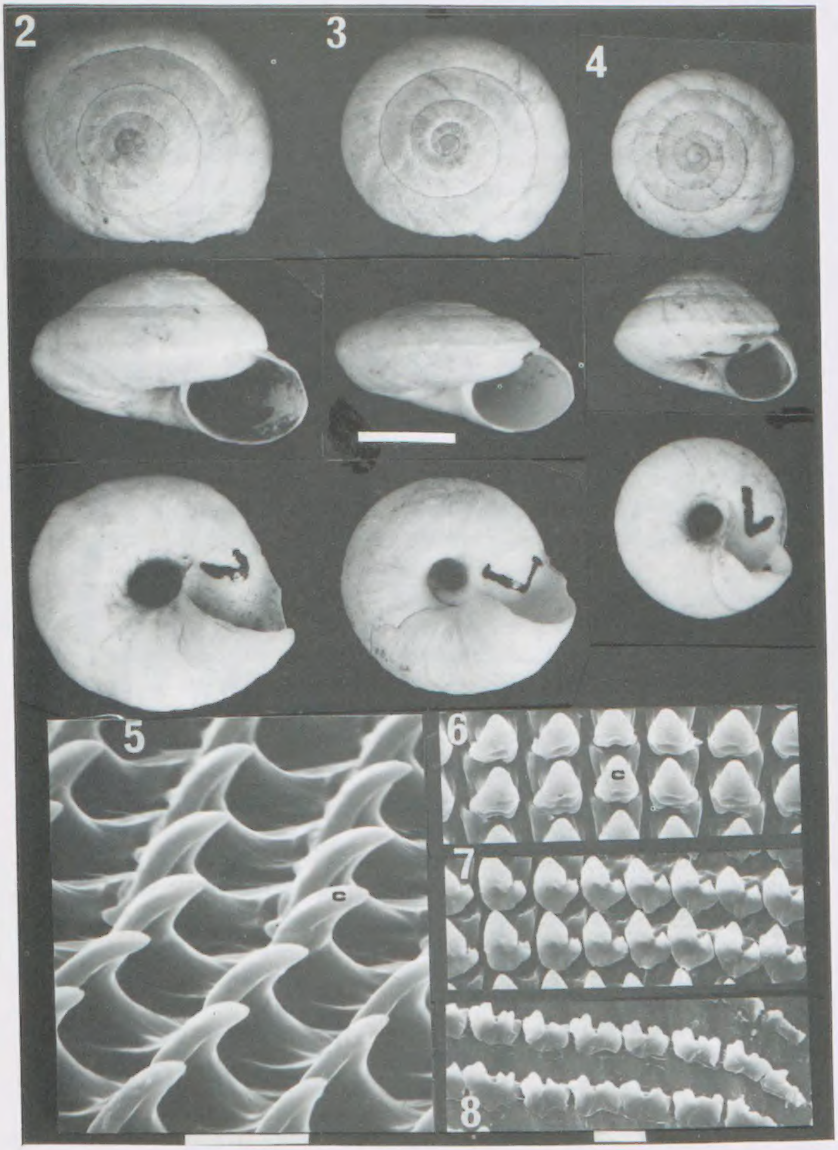


Fig. 1. Canary Islands UTM maps with the geographical distribution of the species; the symbols represent 1 × 1 km squares.

a terminal opening. In transverse section, the penial papilla is formed by two concentric rings separated by a thin cavity but united with a longitudinal septum between them; the outer papilla wall appears to be formed by an invagination of the penis wall and the inner by the thickened epiphallus wall; both papilla walls are united on its proximal and distal ends and also by the longitudinal septum mentioned above. Papilla lumen reduced to a slit.



Figs. 2–8. *Candidula ultima* (Mousson, 1872). **2**, lectotype of *Leucochroa ultima* Mousson, 1872 (ZMZ); **3**, lectotype of *Leucochroa pressa* Mousson, 1872 (ZMZ); **4**, lectotype of *Leucochroa accola* Mousson, 1872 (ZMZ); **5–6**, central tooth (**c**) and first lateral teeth; **7–8**, lateral and marginal teeth. Scale bar: **2–4**, 5 mm; **5–8**, 15 μm.

Vagina united with the dart-sac complex for nearly all its length; only a fifth of the dart-sac complex is free. Distal free part of the vagina very short, normally with three crown-shaped and initially forked digitiform glands, each one can also be unforked to tridentate; the digitiform glands originating close to point where bursa copulatrix duct arises; one specimen had four glands. Distal vagina continues longitudinally in line with the bursa duct and the short free oviduct inserts laterally. The oval bursa copulatrix adheres to the spermoviduct. The diverticle is absent and the bursa duct is long, with initial portion slightly

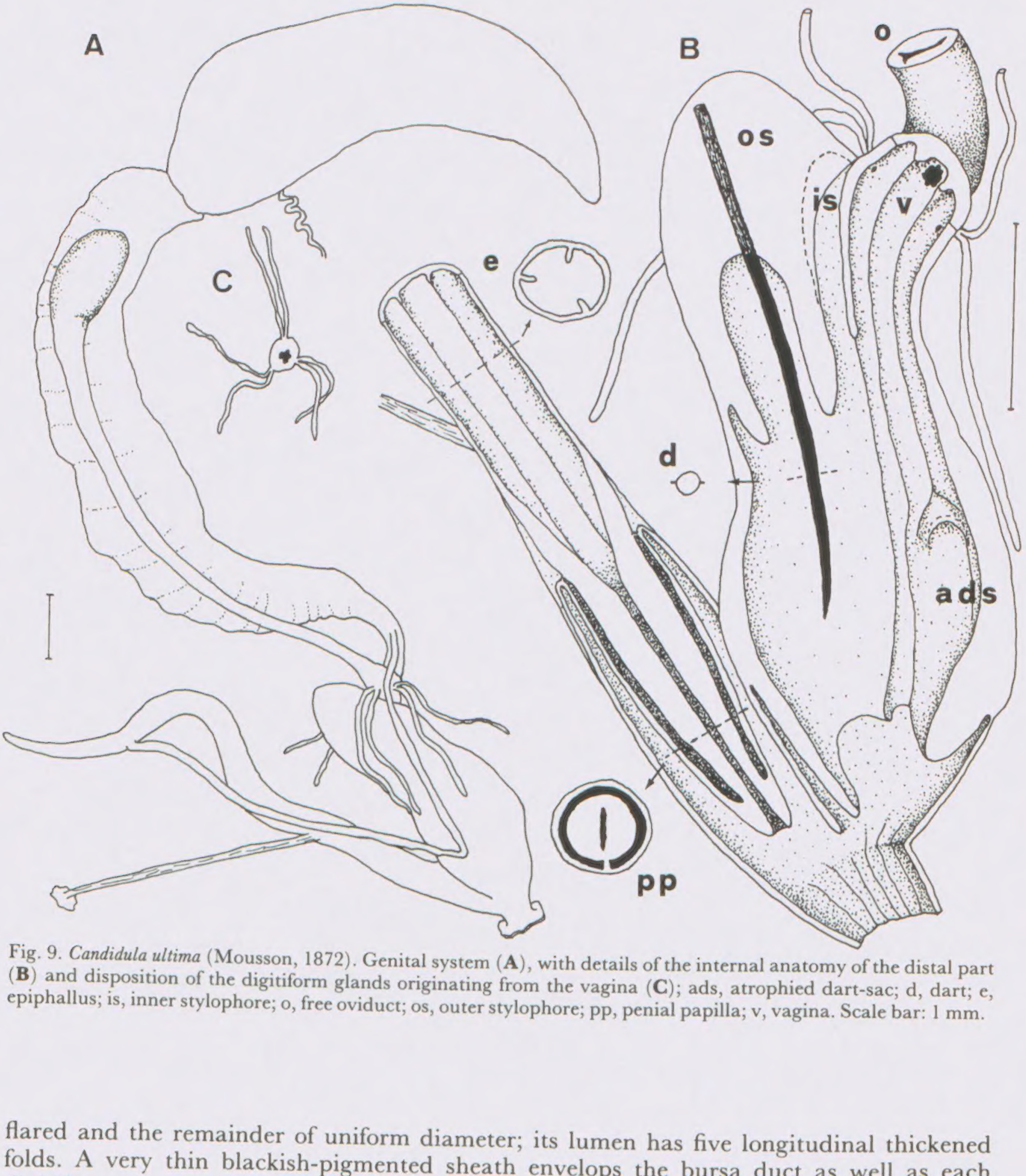


Fig. 9. *Candidula ultima* (Mousson, 1872). Genital system (**A**), with details of the internal anatomy of the distal part (**B**) and disposition of the digitiform glands originating from the vagina (**C**); ads, atrophied dart-sac; d, dart; e, epiphallus; is, inner stylophore; o, free oviduct; os, outer stylophore; pp, penial papilla; v, vagina. Scale bar: 1 mm.

flared and the remainder of uniform diameter; its lumen has five longitudinal thickened folds. A very thin blackish-pigmented sheath envelops the bursa duct as well as each digitiform gland.

Dart-sac complex large and brawny, with an outer dartbearing stylophore containing a hollow and slightly curved dart of circular cross-section (length, ± 3 mm, diameter, 110–120 μm) and with two very narrow wings on the opposite sides respecting the axis. Between the outer stylophore and the vagina a reduced and externally unnoticeable inner dartless stylophore (= "accessory sac") is present, and also an atrophied dart-sac in the opposite vaginal wall. There is a thin muscular bridle between the dorsal side of the dart-sac complex and the spermoviduct (this is not drawn in Fig. 9).

DISCUSSION

Studying its anatomy, we surprisingly found out that *L. ultima*, which has shell characters which resemble the family Sphincterochilidae, is not related to this family but belongs to he thygromiid genus *Candidula* Kobelt, 1871. This placement is established on the basis of its anatomy, mainly in respect of a) the same position of right ommatophore retractor muscle (free from penis and vagina), b) the dart-sac complex with an outer dartbearing stylophore, an "accessory sac" and an atrophied dart-sac in the opposite vaginal wall, and c) the penial papilla, which is similar to that of *C. gigaxi* (Pfeiffer, 1848) or *C. intersecta* (Poiret, 1801).

Leucochroa accola is the smallest of the three Mousson taxa and apparently subfossil. We consider it as a junior synonym of *L. ultima*, as well as *L. pressa*, already previously assumed in the literature, because all forms are very similar conchologycally; apart from the size, the colour, ornamentation and shapes of the shells are very close (Figs. 2–4, 10). Moreover, *accola* is located inside of the *C. ultima* distribution area.

L. accola is a dwarf form of *C. ultima* likely for environmental conditions and it is restricted to the driest area of the island. The aperture area of *C. ultima* has a high correlation with the shell diameter (Fig. 10) and, as Goodfriend (1986) indicates, the aperture area tends to be smaller under drier conditions, probably because of selection for smaller cross-sectorial area to reduce water loss.

An interesting question refers to the presence of *C. ultima* on Fuerteventura. Why not Lanzarote?. Effectively, Lanzarote is practically a part of the same "island edifice" as Fuerteventura, as the depth in the narrow strait between the two islands does not exceed 40 m, and they could be connected in the past. Both islands are volcanic and with similar old age, 17–22·5 Ma in Fuerteventura and 14–15·5 Ma in the southern edifice of Lanzarote (Ancochea *et al.*, 1993; Coello *et al.*, 1992).

The oldest material known of *C. ultima* corresponds to the Upper Pleistocene (25–32 thousand years ago) from "Hueso del Caballo" (in the isthmus of the Jandia peninsula, UTM: 28RES7415) and the northern fossil deposit, from the medium layers of La Costilla sand pit (UTM: 28RFS0073), probably has an age of 10 to 15 thousand years (Holocene; Hutterer, 1990); no material of this species has been found in other fossil deposits, as Barranco de los Molinos (Pliocene deposit: Meco & Stearns, 1981) or Orzola (Lanzarote, Upper Miocene: Gittenberger & Ripken, 1985). This suggests a relatively young invasion of the species from the mainland of Africa to Fuerteventura, posterior to the last glaciation. The immigration perhaps took part by lucky hit, via "swimming islands" and excluded Lanzarote, even we do not know what is hidden under the lava-streams in the West of this island (the area of the spectacular National Park of Timanfaya). On Fuerteventura it had an expansion period correlated probably with a more humid climate (Fig. 1, white squares of La Costilla and Jandia peninsula) and a posterior regression to its present distribution area. That it does not settle in close more humid areas today (as the Jandia massif, with the top at 807 m altitude and annual rainfall of ±300 mm) may be caused by its mountainous conditions, by concurrence of other species or by lack of potential feed. The small *accola* population (only with 5–5¼ whorls) could be the consequence of very arid conditions and apparently vanished due to excessive dryness.

The genus *Candidula* has nine known species endemic to the Iberian peninsula, three chiefly West-European (one of them introduced in the Azores: Backhuys, 1975), one to three endemics to Italy, other three endemics to the Balkan peninsula (Hausdorf, 1988, 1991; Manganelli & Giusti, 1988; Puente, 1994) and one endemic to Fuerteventura (this article). Furthermore, Aparicio & Seddon (in prep.) re-describe three species from Morocco which have comparable shell characters and a similar internal anatomy, expected to be placed in the genus *Candidula*, and Giusti & Manganelli are preparing a paper with similar results

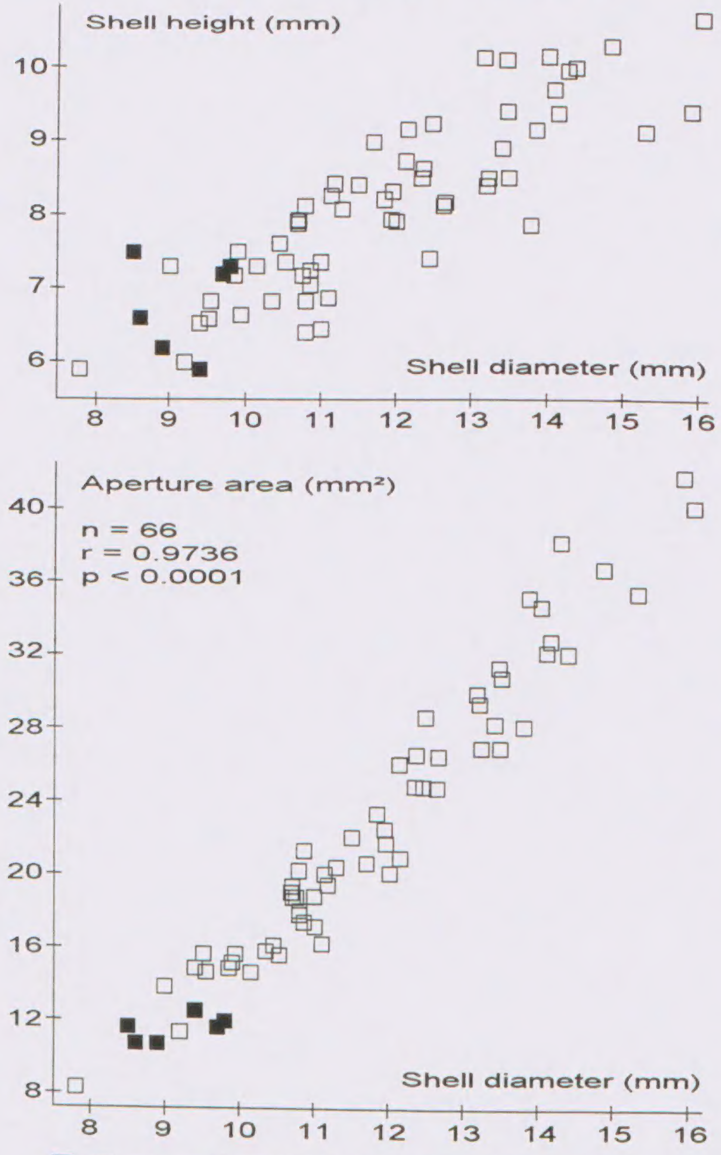


Fig. 10. *Candidula ultima* (Mousson, 1872). Scatter diagram of some shell relations shown in Table 1.

from Algeria. Thus, *Candidula* is a Palaearctic genus with a present disjunct distribution as many other land snails (Giusti & Manganelli, 1984; Seddon *et al.*, 1993, 1994) and a possible centre of diversity located in the Betic-Riffian complex (on basis on its greatest number of species at the present time).

The conchological and anatomical characteristics of the majority of European *Candidula* species are well known (Altimira, 1969; Gittenberger, 1985, 1993; Gittenberger *et al.*, 1970; Giusti *et al.*, 1992; Hausdorf, 1988, 1991; Kerney & Cameron, 1979; Kerney *et al.*, 1983;

Ortiz de Zárate López, 1950; Prieto, 1986; Puente, 1994; Soós, 1924; Zilch, 1960). *C. ultima* and the African species mentioned above differ conchologically from the others by their different shell consistence, colour and ornamentation; the European representatives exhibit a thin-walled shell with regularly arranged radial ribs or striae, and a very variable colour pattern but never have a teleoconch almost uniform white coloured.

The *Candidula* type species, *Helix unifasciata* Poiret 1801, has only two digitiform glands on the side of the dart-sac complex (the remainder species have the digitiform glands around the vagina) and it is the only species without a second (atrophied) dart-sac; therefore Hausdorf (1988) suggested to divide the genus in two subgenera. If this division will be followed, the Canarian species belongs to the unnamed new subgenus.

On the other hand, the different shell characteristics of these African species could be considered as apomorphics, justifying a new taxa of supraspecific level, but similar cases arise with some North African species belonging to other genera, namely with *Helicopsis (Xeroleuca) conopsis* (Morelet, 1876) and *H. (X.) turcica* (Holton, 1802), from Morocco (Aparicio *et al.*, 1992). These species have white, chalky and solid shells, enabling a greater proportion of heat to be reflected (white colouration) and thermic isolation (solid shell). Therefore, we consider these shell characteristics as a nice case of convergent adaptation with the Sphincterochilidae to the desert habitats and a similar way of life.

This case is an example of the environmentally induced land snails radiation ability, to add to some already known, as the environmental advantages by "changing position" of right ommatophore retractor muscle (Schileyko 1972, 1978) and others whose adaptive convergence (not demonstrated) is possible because they are found in phylogenetically distant genera, as the ones signed in Ibáñez *et al.* (1995: 133, A–E). These cases complicate the understanding and befriend different opinions on aspects of the Hygromiidae systematic, as those of Hausdorf (1988), Nordsieck (1987, 1993) and Schileyko (1978, 1991). As Giusti *et al.* (1992) indicates, only the consideration of a larger number of characters (i.e. anatomical, genetical, cytological and biogeographical) could promote better understanding of the phylogeny of Helicoidea.

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J. Conch., Lond. **35:** 467–471 (1996)

THE ECOLOGICAL STATUS OF *PUPILLA MUSCORUM* (LINNÉ) IN HOLOCENE OVERBANK ALLUVIUM AT KINGSMEAD BRIDGE, WILTSHIRE

P. Davies[1]

Abstract: Sub-fossil samples from Holocene overbank alluvium commonly contain *Pupilla muscorum*, and there is uncertaintly as to whether the species is representative of dry or wet ground. Multivariate analysis of 44 sub-fossil samples from overbank alluvium suggests that *Pupilla* is behaving as a dry ground species in such contexts, and that the species may be indicative of certain land-use regimes.

INTRODUCTION

Analysis of sub-fossil Mollusca from prehistoric ditch fill deposits characteristically show *Pupilla* as a component of an open, short-turf grassland assemblage (eg. Whittle *et al.* 1993, profile ED IV at Easton Down Long Barrow). This accords with its usual modern day habitat preference for grassland (particular when bare ground exists), walls and sand dunes (Evans 1972). However, at the present time *Pupilla* can occasionally be found in marshes (Boycott 1934, Ant 1963), and is common in damp hay meadows in the Netherlands (Mörzer Bruijns *et al.* 1959). Presence in wet ground habitats has also been detected from sub-fossil samples belonging to the late-glacial and early post-glacial (Kerney *et al.* 1964, Evans 1972). Recently, it has become apparent that *Pupilla* is also often present in overbank alluvium deposits of prehistoric and historic age. Evans *et al.* (1992) used *Pupilla* to characterise one of their recurrent wet-ground taxocenes from Holocene overbank alluvium, but were unsure of what its presence meant in terms of environmental reconstruction. Environmental reconstruction depended upon whether one assumed *Pupilla* was representing dry ground or wet ground.

This paper presents a numerical analysis of sub-fossil Mollusca recovered from Holocene overbank alluvium and demonstrates that the ecological status of *Pupilla* found in such contexts can be determined.

METHOD AND RESULT

Three sub-fossil sequences through overbank alluvium at Kingmead Bridge on the River Wylye, Wiltshire (NGR SU 363069) have been analysed by the author. Only one of these sequences (KBF) has been published (Evans *et al.* 1992), although full details of the other two (KBB and KB240) can be found in Davies (1992). As part of the analysis the three sequences

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were combined into a single species/sample data matrix and Detrended Correspondence Analysis (Hill 1979) used to numerically compare each of the 44 recovered samples. A resultant ordination diagram grouped similar samples. In addition, the data matrix was inverted allowing species to be compared. The resultant ordination diagram this time grouped similar species (Figure 1). Similar, in this sense, means species that behave in a similar manner.

It can clearly be seen that the data made ecological sense with reference to modern day molluscan species ecologies. Six species groupings are apparent. From right to left these are:

Group F:	*Pisidium personatum*, *P. casertanum*, *P. obtusale* and *Valvata cristata*. All slum aquatic species (Sparks 1961).
Group E:	*Anisus leucostoma*, *Lymnaea truncatula* and *Vertigo antivertigo*. The first two species are amphibious (Evans 1972, Robinson 1988), the last requiring abundant moisture and restricted to fens and marshes in the present day (Kerney and Cameron 1979).
Group D:	*Vallonia pulchella*, *Carychium minimum*, *Zonitoides nitidus* and Succineidae. The first of these prefers wet places, the others are obligate hygrophiles.
Group C:	*Euconulus alderi*, *Vitrea contracta*, *Discus rotundatus*, *Ashfordia granulata* and *Carychium tridentatum*. Terrestrial Mollusca which are relatively catholic in their requirements but which prefer damp places.
Group B:	*Cepaea/Arianta*, *Cochlicopa lubrica*, *Nesovitrea hammonis*, *Trichia hispida*, Limacidae (represented by slug plates) and *Vertigo pygmaea*. Catholic species with no particular preference for wet-ground.
Group A:	*Pupilla muscorum*.

DISCUSSION

Axis 1 of Figure 1 clearly represents a dry→wet environmental gradient from left to right. One must therefore conclude that *Pupilla muscorum* is the most xerophilic species represented. Clearly, in the three sequences analysed, the presence of *Pupilla* in any particular sample indicates a dry ground aspect to the environment rather than a wet ground aspect.

On the first level then, whether *Pupilla* in these alluvia contexts represents dry ground or wet ground, the answer seems to be emphatically dry ground. At the second level however, what this means in terms of environmental recontruction is slightly more difficult to assess. The presence of *Pupilla* can not infer dry ground *in toto*, since the context is alluvial and the predominant species recovered are usually obligate or preferential wet ground species. One option is that the presence of *Pupilla* infers the presence of dry ground in an otherwise wet ground landscape, in other words the close juxtaposition of wet and dry microhabitats in a wet ground macrohabitat. The translation from living assemblages (wet and dry in close juxtaposition) to a single death or sub-fossil assemblage (showing ecological mixing of the two) is a possibility. However, ecological mixing of this type is not likely since *Pupilla* (when present) is virtually always the only xerophilic component in alluvial assemblages. Species such as *Vallonia costata*, *Vallonia excentrica* and *Helicella itala* are usually not represented. In other words, apart from *Pupilla*, the rest of the recovered Mollusca usually constitute a discrete and coherent wet ground suite.

The second option is that the presence of *Pupilla* indicates *behavioural* mixing. Robinson (1988) suggested that different species of Mollusca could live in the same location but be active at different times of year as environmental conditions changed. In this case, *Pupilla* may therefore indicate seasonal aspects to the environment, the majority of species active

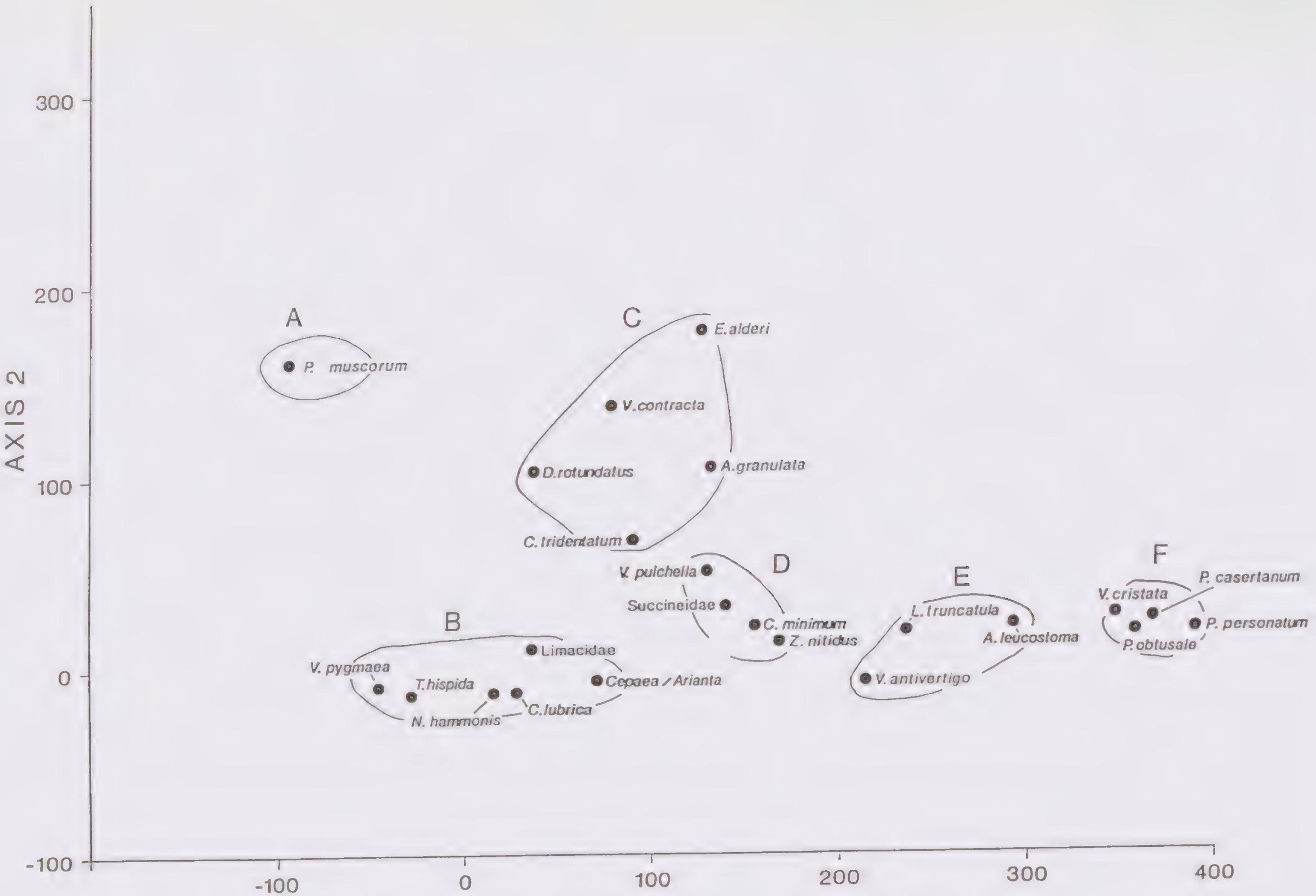

Fig. 1. DCA species ordination plot from 44 sub-fossil samples through Holocene overbank alluvium at Kingsmead Bridge.

through autumn, winter and spring when conditions on the floodplain are wet, but *Pupilla* active *only* during the dry summer months when high insolation and lower rainfall promotes very dry, broken ground. Such dry and broken ground is parlticularly evident in floodplains in late-spring and summer following winter/spring overbank alluviation. Spring or summer ploughing or hay cropping may similarly leave bare, highly-insolated surfaces. whatever the cause or land-use regime, the interpretation remains the same. *Pupilla* indicates a very particular type of ground surface (dry, cracked, bare) during the summer months. If this is the case, one could surmise that no other xerophile apparently has the ability to exploit these seasonal circumstances *and* tolerate or survive the long months of wetness.

CONCLUSION

Numerical analysis and species ordination plots seem to indicate that when *Pupilla* is recovered from Holocene overbank alluvium it may be considered a xerophile. In addition, it has been argued that this can perhaps best be explained by invoking behavioural rather than ecological mixing. In particular, it is considered that *Pupilla* may only be active during summer months when dry, broken and bare ground is present on the floodplain. In conclusion, one can recognise that this is obviously an hypothesis which can be tested by modern ecological study.

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J. Conch., Lond. **35:** 473–481 (1996)

DEEP WATER XYLOPHAGAIDAE (PELECYPODA:PHOLADACEA) FROM THE NORTH ATLANTIC WITH DESCRIPTIONS OF THREE NEW SPECIES

R. Harvey[1]

Abstract: Three new species of obligate wood boring bivalves of the genus *Xylophaga* are described from depths greater than 1000 m in the North Atlantic. *Xylophaga ricei* n.sp. occurred in wood panels deployed for *c.* 20 months on the seabed South of Madeira at a depth of 5000 m. *X. anselli* n.sp. and *X. gagei* n. sp. were discovered in wood fragments which had been heavily bored by *Xyloredo ingolfia* Turner, 1972, trawled from the Rockall Trough to the West of the British Isles.

Key words: North Atlantic, Wood borers, *Xylophaga*, New species, Deep water.

INTRODUCTION

Members of the family Xylophagaidae are obligate borers in a variety of plant materials including wood. The majority of the 3 genera and around 40 known species have been recorded from depths greater than 200 m (Hoagland & Turner, 1981; Knudsen, 1961). The deep water species have been comprehensively treated by Knudsen (1961) who described 17 new species of *Xylophaga* from 545–7250 m recovered by the *Galathea* expedition, and listed all 30 species in this genus known at that time. Fifteen of the *Galathea* species were each recovered from a single station, and several were described on the basis of only one specimen. Subsequently, two new genera have been added to the family; *Xyloredo* (Turner, 1972a) and *Xylopholas* (Turner, 1972b). Many species appear to have a restricted geographical distribution, possibly the result of the apparent absence of a planktotrophic larva, and a tendency to retain the postlarvae attached to the adult. The relatively small number of samples take in deep water however, combined with a low probability of encountering wood fragments in trawls, may partly explain the known species distributions. Intensive sampling with a variety of trawls since 1973 in the Rockall Trough, N.E. Atlantic, by the Scottish Association for Marine Science (SAMS), has recovered only a few wood fragments with boring bivalves.

Experimental placements of wood panels by submersible have shown that settlement of larvae declines rapidly in the first few cm above the seabed (Muraoka, 1966; Turner, 1973). The development of the *Bathysnap* time-lapse camera system (Lampitt & Burnham, 1983) has provided a convenient platform for the deployment of wood panels on the seabed, resulting in the collection of several hundred specimens of postlarvae and adults of a new species of *Xylophaga* described here. This discovery prompted a study of trawled wood fragments in the SAMS collections, the results of which also form the subject of this paper.

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ABBREVIATIONS

BM (NH)	The Natural History Museum, London
NMSZ	National Museums of Scotland, Edinburgh
NMW	National Museum of Wales, Cardiff
SAMS	Scottish Association for Marine Science, Oban
SOC	Southampton Oceanography Centre
ZMUC	Zoological Museum, University of Copenhagen

SYSTEMATIC DESCRIPTIONS

Family XYLOPHAGAIDAE

Xylophaga ricei n.sp.

Figs. 1A–E, 2, 4A

Type material: Holotype (whole animal) BM(NH)1996021. Paratypes BM(NH) 1996022/1–8 including two SEM specimens. Further material lodged with NMSZ, NMW, ZMUC and in SOC and SAMS collections.

Type locality: Institute of Oceanographic Sciences 'Discovery' station 12174#100, Madeira Abyssal Plain, 31°N, 20°W, *c.* 5000 m. Specimens boring into wood panels deployed on *a Bathysnap* camera frame, recovered 21.4.92.

Description: Shell fragile, white and semi opaque in most specimens, possibly an artifact of fixation. Umbo distinctly higher than the posterior–dorsal margin. Beak meets the anterior margin of the shell at an angle of *c.* 100 degrees, extending just under half the distance to the ventral margin in the majority of specimens (Fig. 1A). Ribs on the beak separated by spaces approximately 1–1·5 × the width of the ribs, measured at the midpoint of their length (Fig. 1C). Ribs number from 10 in the smallest to 19 in the largest individual. Umbonal reflection well reflected, almost touching the anterior part of the umbo. Mesoplax small and vertical, comprising two almost flat triangular plates having a slight ventral curvature at the anterior edge (Figs. 1B, 1D)). These bear a very fine transverse sculpture. Protoconch clearly visible in most specimens, measuring approximately 0·3 mm in length (Fig. 1D). Posterior-dorsal margin slightly compressed and reflected, the mantle tissues bulging. In dorsal view, the posterior part of shell is only slightly compressed, curving gently to the posterior gape, with a fine concentric sculpture. A coarser sculpture, originating from the ends of the oblique ridges on the anterior slope, is superimposed upon this (Fig. 1A). Umbonal-ventral sulcus shallow. Internally, umbonal-ventral ridge segmented, terminating in a small condyle (Figs 1E, 4A). Posterior muscle scar large, extending just over half way to the ventral margin, and patterned with markings radiating from the anterior edge. siphon protruding in most specimens, extending up to twice the shell length. Inhalent opening furnished with two rings of cirri, thirteen in each ring on both specimens examined with SEM. Exhalent opening slightly smaller, subterminal and bearing six cirri on the smaller individual, eight on the larger. Faecal pellets agglutinated to form a chimney around the siphon. Maximum shell length 6·30 mm, minimum 0·47 mm. Holotype 5·0 long, with siphon extended.

Derivation of name: The new species is named in honour of Dr Anthony L. Rice, in recognition of his contribution to deep sea benthic biology.

Habitat: Strips of pine 35 mm wide by 12 mm thick and a tropical hardwood 40 mm wide 15 mm thick strapped to a *Bathysnap* camera frame which rested on the seabed from 3rd August 1990 to 21st April 1992, a total of 627 days immersion. Over 400 specimens were extracted from the habitat, the majority with soft parts preserved.

Remarks: This species resembles *Xylophaga galatheae* Knudsen, 1961, in the form of the mesoplax. *X. galatheae* is known from one *Galathea* station in the Tasman Sea at a depth of

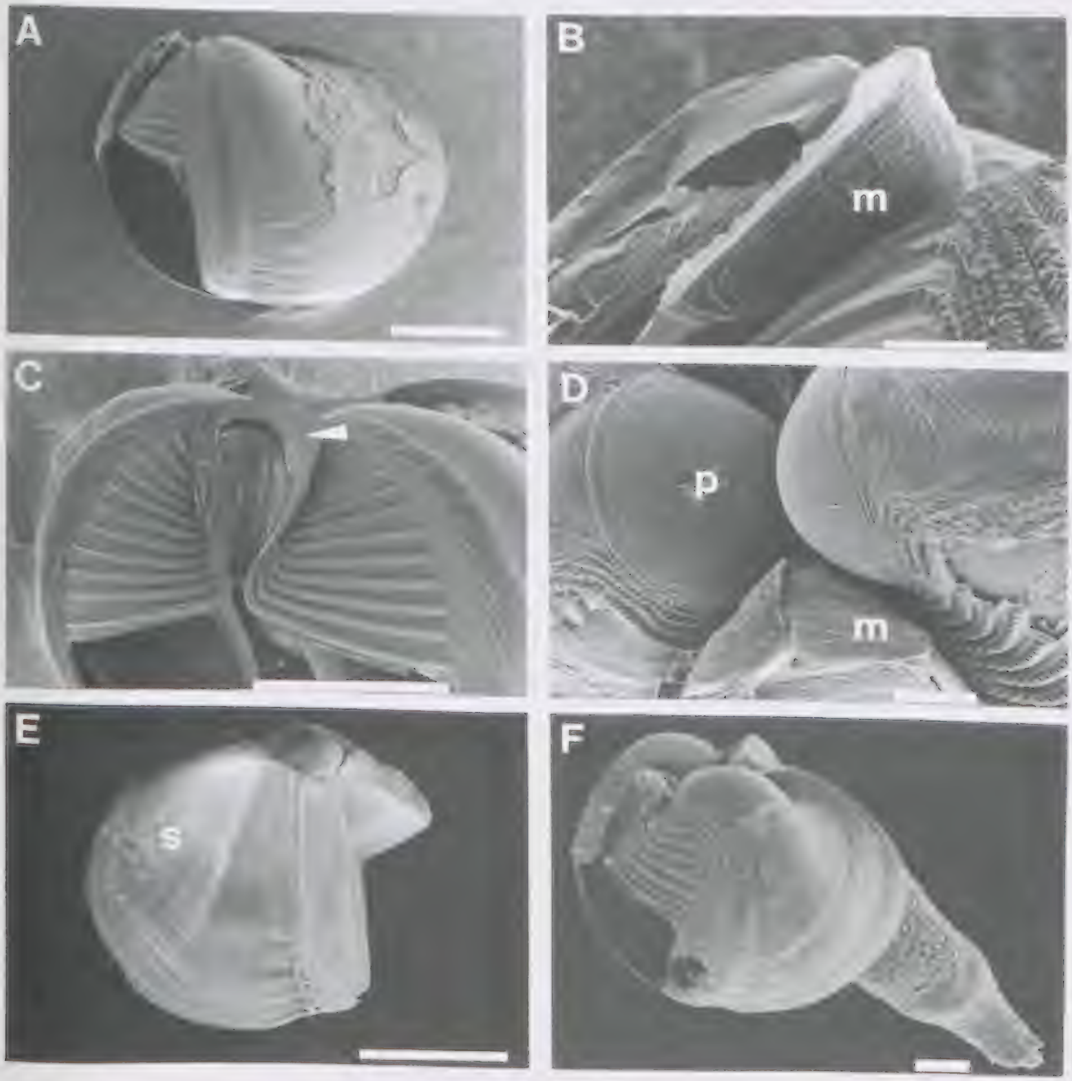

Fig. 1. A–E: SEM micrographs of *Xylophaga ricei*. A. Lateral view of left valve of paratype BM(NH)1996022/6; scale bar = 1 mm. B. Mesoplax (m) of same specimen; scale bar = 0·1 mm. C. Beak of same specimen with mesoplax (arrowhead) partly covered by anterior adductor muscle; scale bar = 1 mm. D. Umbo region showing mesoplax (m) and protoconch (p); scale bar 0·1 mm. E. Interior of left valve of paratype BM(NH) 1996022/7 showing scar of posterior adductor (s); scale bar = 1 mm. F. *Xylophaga anselli*. SEM micrograph of whole animal paratype NMSZ 1996043.2 from left side. Note small protoconch and the cirri at end of siphon; scale bar = 0·1 mm.

4530 metres. Examination of paratypes held in the ZMUC showed that in *X. galatheae* the spaces between the ribs on the beak are 2–4 times the width of the ribs, c.f. 1–1·5 times in *X. ricei*. The similar size of specimens of both species allowed close comparison of this and other shell features. The posterior-dorsal margin of the shell is more compressed and extends above the umbo in *X. galatheae*, giving the shell a ‘tall’ appearance. In contrast, the shell of *X. ricei* is more elongate posteriorly. The mesoplax figured by Knudsen (1961) is much more curved than that in *X. ricei*, and the umbonal reflection is less reflected in his paratypes than

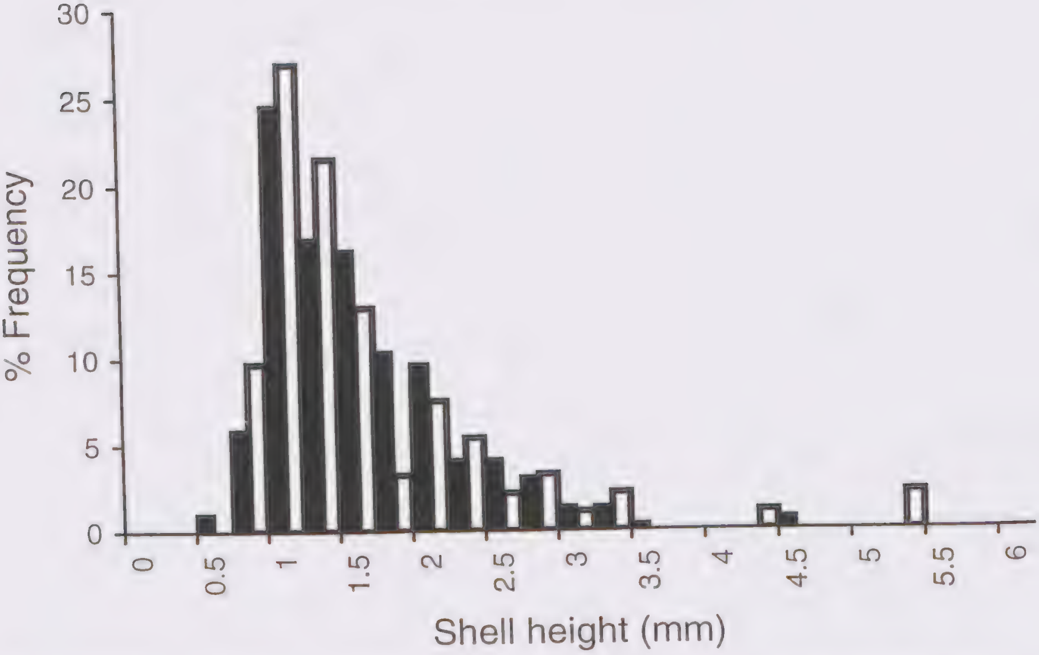

Fig. 2. Size-frequency histograms of *Xylophaga ricei* from hardwood (dark bars, n = 289) and pine (pale bars, n = 93) panels after 20 months immersion.

in the new species. The condyle on the umbonal ventral ridge was not as distinctively large in the paratypes of *X. galatheae* which I examined as in the holotype figured by Knudsen. Furthermore, the umbonal reflection in these paratypes did not touch the umbo posteriorly, in contradiction to the original description of the holotype – the only specimen bearing a mesoplax. Unfortunately the small twigs containing *X. galatheae* were originally preserved dry, and the siphon is not known in this species.

Although recently settled postlarvae measuring <0·5 mm were common on the wood panels, none were seen attached to adults, in contrast to several described species and a new species described below. The largest specimens were recovered from the pine panel, although the size frequency distributions of the two samples (Fig. 2) were not significantly different (χ^2 test; P=0·33). The hardwood panel had been so extensively bored that parts of it had crumbled away and some larger specimens may therefore have been lost. Although the two types of wood were of different hardness, this appeared to have had no effect on shell morphology.

Xylophaga anselli n.sp.

Figs. 1F, 3A, 4C

Type material: Holotype (whole animal) NMSZ 1996043.1. Paratypes NMSZ 1996043.2–6, including one SEM specimen. Further material, including fragments of the habitat, deposited with BM(NH), NMW, ZMUC and in SAMS and SOC collections.
Type locality: SAMS station AT 428, Hebridean Slope, 56° 34′N, 09° 31′W, 1370 m, 21.11.1991.
Other material examined: SAMS station AT 413, 57° 19′N, 10° 23′W, 2195 m, 17.2.1991, East of Anton Dohrn Seamount. Both this and the type material taken with an Agassiz trawl.

Description: Shell minute, white, semi opaque and fragile. Beak extending to around one third of the shell height, and with up to 11 ridges, closely spaced ventrally but become more widely spaced dorsally. Umbonal reflection poorly developed, not touching the anterior of the umbo. Beak often 'retracted' owing to the contraction of the anterior adductor muscles which bulge dorsally (Fig. 1F). Mesoplax plates not seen, but a vertical fan-shaped periostracal mesoplax appeared to be developing in one specimen. Anterior and posterior parts of the shell not strongly marked off from one another due to the shallow umbonal ventral sulcus. Posterior opening of shell gaping widely in most individuals, with mantle bulging dorsally. Umbo slightly higher than the very compressed and reflected posterior dorsal margin. Posterior part of shell sculptured with fine concentric ridges, and coarser sculpture corresponding with the ends of the oblique ridges of the anterior slope. Protoconch golden brown, transparent, 0·2–0·25 mm long. Umbonal ventral ridge segmented, terminating in a condyle *c.* 2 × the width of the ridge. Posterior adductor muscle scar large, extending over three quarters of the way to the ventral margin and patterned with lobes radiating from the anterior edge. Siphon extended in most specimens, with only one opening visible at the tip and up to 12 cirri. Two siphonal canals present near siphon tip, suggesting the presence of a subterminal exhalent opening. Siphon surrounded by a chimney of agglutinated faecal pellets enveloped in a pink periostracum, making it possible to remove the chimney intact. Chimney tip often protruding slightly at the surface of the wood. One of the largest specimens, 0·92 mm long, with cirri visible at the siphon tip was selected as the holotype. The majority of individuals are under 0·7 mm in length, but are distinctly different from the following species, even at a length of 0·35 mm when metamorphosis is clearly complete.

Derivation of name: This species is named in honour of Dr Alan D. Ansell, in recognition of his many contributions to malacology which include boring in gastropods and a variety of pholadids.

Habitat: Type recovered from fragments of a fruit box(?) about 5 mm thick, with extensive borings of this species, other Xylophagaidae and *Teredo malleolus*. The second sample (AT413) comprised a length of tree branch *c.* 15 cm long by 7 cm diameter, with a similar mixture of wood borers, although *X. anselli* was much less abundant than the other species.

Remarks: This species was found in profusion at the type locality, mainly boring straight down into the flat surface of the wood at right angles to the grain. Many specimens had only recently metamorphosed, and newly settled postlarvae were scarce, indicating recent infestation of the wood by this species. The absence of a calcified mesoplax probably results from the specimens all being juveniles. A similar characteristic occurred in *Xyloredo ingolfia* juveniles recovered in the same sample. In addition to the calcareous tube in *Xyloredo*, the two species can easily be separated by the size of the protoconch, the form of the siphon; cirri being absent in *Xyloredo ingolfia*, and the presence of a condyle on the umbonal-ventral ridge in *X. anselli*.

Xylophaga gagei n.sp.

Figs. 3B–D, 4B

Type material: Holotype (whole animal) NMSZ 1996111.1. Paratypes NMSZ 1996111.2–5, including one SEM specimen. Further material and wood fragments deposited with BM(NH), NMW, ZMUC and in SAMS and SOC collections.

Type locality: SAMS station AT 428. Further material from station AT 413 (see *X. anselli* above for station details).

Description: Shell opaque, large specimens having a somewhat dirty white appearance, with small cracks in the shell. Beak slightly less than half the shell height with 21 ridges in the largest specimen excavated (5·6 mm long). Ridges around half the width of the interstices in juveniles, specimens >3 mm long tending to have more closely spaced ridges ventrally. Umbo distinctly higher than posterior dorsal margin, which is only slightly reflected.

Posterior region of shell with a fine concentric sculpture together with a coarser sculpture originating from the end of the oblique ridges of the anterior slope. Umbonal reflection slight, not touching the frontal slope and continuing to the mesoplax. Periostracum brownish along the margin of the mesoplax and its suture with the umbonal reflection. Mesoplax comprising two elongate triangular plates, curving medially and ventrally, forming an arch in most individuals, owing to the contraction of the anterior adductors. A sculpture of fine anterio-posterior ridges is present on the mesoplax in specimens >3 mm. Anterior slope well marked off from posterior region of the shell by a ridge behind the umbonal–ventral sulcus, and a sharp change in angle as seen in dorsal view (Fig. 3B). Umbonal–ventral ridge translucent and segmented, its course being clearly visible on the external surface of the shell. It is terminated by a conspicuous condyle slightly wider than the ridge. Posterior adductor muscle scar extending forward more than half way to the umbonal–ventral ridge and around two thirds of the way towards the ventral margin, with oblique transverse markings. Siphon broad and tending to be retracted, but sufficiently extended in one specimen to discern two rings of cirri, with at least 20 in the outer ring on the terminal inhalent opening. The inner tentacles appear to be longer. Exhalent opening smaller, subterminal, not expanded in any individual, and furnished with cirri. Chimney of faecal pellets apparently lacking. Protoconch (Fig. 3D) *c.* 0·35–0·5 mm long, colourless and

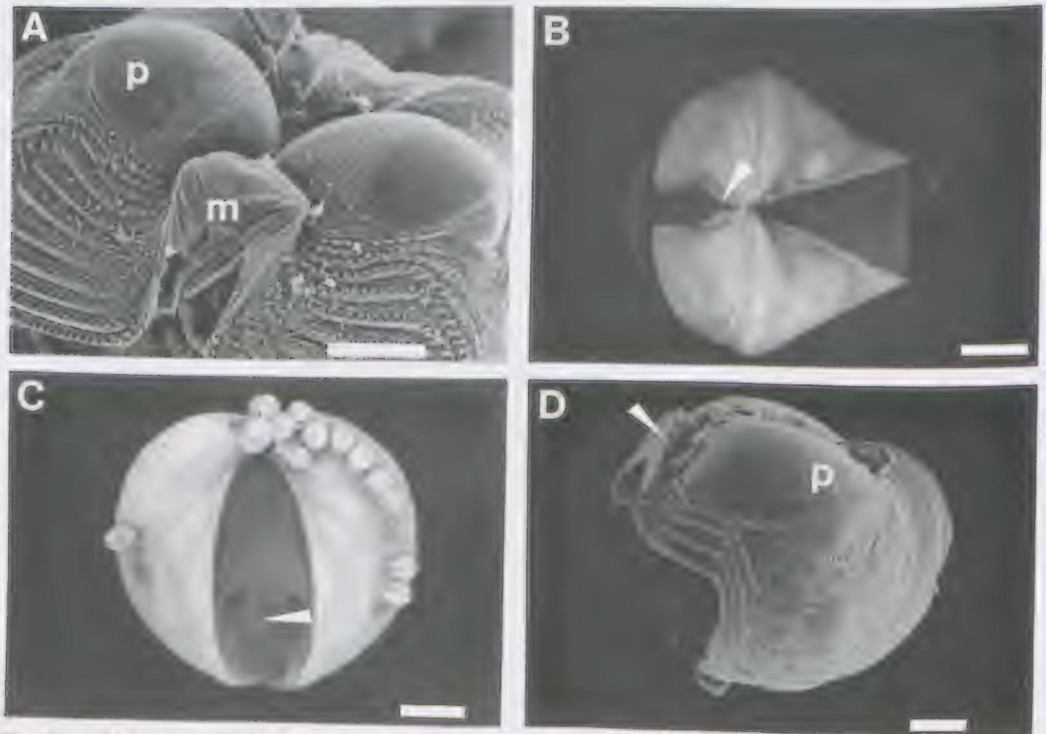

Fig. 3. A. SEM micrograph of *Xylophaga anselli* paratype NMSZ 1996043.2 showing the protoconch (p) and uncalcified mesoplax (m); scale bar = 0·1 mm. B. Dorsal view of *Xylophaga gagei* paratype NMSZ 1996111.2 showing the prominent ridge separating the frontal slope from the posterior region of the shell and the small mesoplax (arrowhead); scale bar = 1 mm. C. Posterior view of another *X. gagei* paratype NMSZ 1996111.3 with postlarvae attached to the shell. The shorter exhalent siphon is indicated by an arrowhead; scale bar = 1 mm. D. SEM micrograph of a recently settled juvenile *X. gagei* paratype NMSZ 1996111.4 with mesoplax (arrowhead) and protoconch (p); scale = 0·1 mm.

transparent in juveniles, opaque in adults. Holotype 3·1 mm long, with 5 postlarvae 0·5 mm long attached to its umbo by their ventral margins.

Derivation of name: This species is named in honour of Dr John D. Gage, in recognition of his contribution to deep sea benthic biology.

Habitat: As for *X. anselli* above. Hundreds of individuals remain in the wood recovered from the type locality, where it was the most abundant *Xylophaga*. In the sample from AT 413, neither *Xylophaga* species was abundant, but several individuals of *X. gagei* >3 mm long were present, with attached juveniles.

Remarks: The majority of specimens are less than 1 mm in length. Many postlarvae just beginning to metamorphose into a xylophagainid form are probably this species, as the large colourless and transparent protoconch is distinctly different from *X. anselli* above and

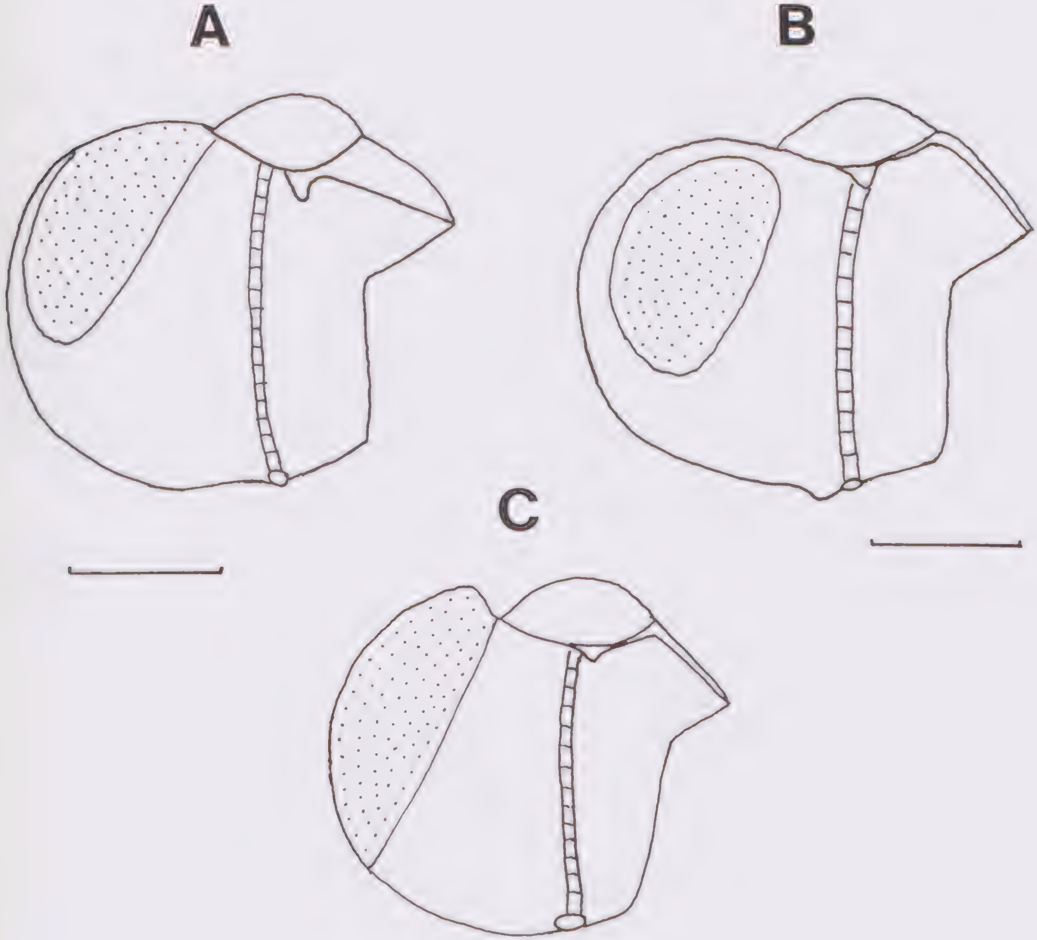

Fig. 4. Interior views of the left valves of the three *Xylophaga* species to show the impressions of the posterior adductors and the relative sizes of the condyles which terminate their umbonal–ventral ridges. A. *X. ricei*. B. *X. gagei*. C. *X. anselli*; scale bars = 1 mm.

Xyloredo (see below). A good growth series is available for *X. gagei* from the type locality, and several of the larger individuals carry opaque postlarvae. Additional postlarvae which matched these in appearance were found attached to the wood fragments. This indicates the presence of at least two generations, in contrast to *X. anselli*. The varying size of the protoconch may suggest a plasticity in the mode of reproduction in this species, with a switch to brooding and a larger protoconch in appropriate conditions.

This species resembles *X. panamensis* Knudsen, 1961, known only from a single dried up specimen. The general shell outline and form of the mesoplax are somewhat similar. Comparison of *X. gagei* of a similar size to the type figured by Knudsen (1961) revealed that in *X. gagei* the beak extends further forward and ventrally, the posterior adductor scar is larger, and *X. panamensis* lacks a condyle on its umbonal–ventral ridge.

Xyloredo ingolfia Turner, 1972

Type material: (not examined)
Type locality: Ingolf station 67, South of Eyrabakki, Iceland, 61° 30′N, 22° 30′W, 1783 m.
Other material examined: SAMS stations ES 411, 54° 40′N, 12° 06′W, 2906 m, 16.12.1990; AT 413 and AT 428 (as above).
Description: Tube fragile, with concentric rings. Conical calcareous 'figure of 8' shaped opening at surface of wood. Tubes frequently double back on themselves. The largest specimen removed measures 2·8 mm long × 2·5 mm high. This has a beak less than half the shell height, with about 20 closely spaced ridges. Umbonal reflection well developed, forwardly projected and reflected. Umbonal–ventral sulcus shallow and indistinct, not dividing the shell into two. Umbo just higher than the slightly reflected posterior slope. Imprint of posterior adductor muscle visible through shell, extending to three quarters of the shell height. Mesoplax periostracal in the smaller specimens, but represented by two small separate plates in larger ones, lying on the anterior adductor. Protoconch yellow 0·4 mm long, making the postlarvae distinct from those of the other xylophagaidae recovered from these stations. Siphon long, swollen and covered by periostracum posterior to the shell, and bifurcated at the tip with no sign of any cirri on either opening.
Habitat: A variety of trawled wood fragments.
Remarks: The small size of the specimens makes it difficult to extract them complete with the fragile tube. They are comparable in size with the types described by Turner (1972a). Many more specimens remain in the wood fragments. Apart from the type locality, this species is known from the North West Atlantic *c.* 38°N, 69°W, 3602 m (Dean, 1992). The new specimens are therefore the first to be recorded from British waters and suggest that this species is likely to be found throughout the North Atlantic.

DISCUSSION

The new species described here bring the number of known species of *Xylophaga* to 39. Planned deployments of wood panels on *Bathysnap* or similar free vehicles on the European margin will, it is hoped, provide additional information on zoogeography and life history in this curious family. The rapid growth of *X. ricei*, achieving a length of 6·3 mm in a maximum of 20 months at a depth of 5000 m, indicates the potential at this depth for growth rates comparable to those seen in shallow water, given an adequate food supply. Larval life history in the Xylophagaidae remains elusive, but the application of DNA sequencing could clarify whether the postlarvae found attached to some individuals are their own offspring. The apparent absence of this brooding habit in some species e.g. *X. ricei*, indicates a range of solutions to the problem of finding and then maintaining a population on a scattered food source in the deep ocean. An alternative hypothesis would involve a degree of plasticity in development, with initial settlement from planktotrophic larvae followed by a switch to brooding once a critical body size is reached. The attainment of this size would of course depend on the availability of an adequately large wood fragment.

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Dr B. J. Bett and Dr A. L. Rice of the Southampton Oceanography Centre kindly made the *Bathysnap* material available to me. I thank Dr John Gage and Fay Harvey for their encouragement, and Dr Irina Grigolava for Russian translation. Dr Tom Schiotte of the Zoologisk Museum, Copenhagen kindly loaned me type material, for which I am grateful. The Scottish Association for Marine Science is partly supported by a grant in aid from the U.K. Natural Environment Research Council.

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SYSTEMATIC REVISION OF THE FAMILY PHYLLIDIIDAE IN THE INDIAN OCEAN PROVINCE: PART 1 (OPISTHOBRANCHIA: NUDIBRANCHIA: DORIDOIDEA)

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(*Accepted for publication, 20th October, 1996*)

Abstract: Ten species belonging to three genera of the family Phyllidiidae are redescribed and one new species is described. External dorsal and ventral characters and internal digestive morphology have been examined, and are shown to be constant for each species; despite slight variations, internal morphology correlates with external characteristics, demonstrating that species can be separated by careful observation of external features. In addition, a combination of external characters can also be used to assign species to their respective genera, including tubercle arrangement, body colour and pattern, rhinophore shape and colour, and oral tentacle and head morphology.

Key words: Indo-Pacific, taxonomy, *Phyllidia*, *Phyllidiella*, *Fryeria*.

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Acknowledgements
References

INTRODUCTION

This study on the systematics of the family Phyllidiidae began in the 1980's when it was realized that the taxonomy of the family was somewhat complicated. Large recent

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collections from the Indian Ocean province have formed the baseline to this study, which examines in detail external and internal (digestive) morphology. Camera lucida drawings of almost every specimen have been prepared, and compared with each other and with available data. The original intention was to begin with colour groups, as the species within each group appeared to be confused with each other rather than with other species of other colour groups. This necessitated comparisons with the Pacific fauna and the task grew out of proportion, although it was found possible for some groups (e.g. the '*ocellata*' and '*rueppelii*' colour complexes) but impossible for most others. Hence, some Pacific species are included in this first part of a descriptive review of the Indian Ocean fauna.

As the drawings and manuscripts of this paper neared completion, Brunckhorst (1993) published a review of the Phyllidiidae in which he recognized 25 valid species, of the 73 described to date, and created a further 22 new species. Brunckhorst's research was based on "more than 1300 specimens", of which "more than ten of each species" were dissected; it should be noted, however, that 21 of his species were represented by fewer than ten specimens, and eleven by only one or two. Unfortunately, Brunckhorst's (1993) paper is poorly illustrated and it is difficult to draw independent conclusions regarding his species synonymies. Phyllidiid nudibranchs have no hard parts; hence, differences in colour, pattern, external and internal morphologies, ecology, and zoogeography are all important in defining each species. Illustration becomes a necessity, as photographs and drawings are objective records of this diverse information. As a result, Brunckhorst's synonymies are not reallocated in this work except for those which are considered synonymous with the species described here. As work on this family progresses, a complete list of synonymies will emerge.

During the course of this work, it was found that, despite preservation, there was little variability in a species, and that the extremes of these variations rarely overlapped with closely similar species. This observation applies to both external and internal characteristics. Alpha-taxonomy is a prerequisite to higher taxonomic and phylogenetic studies, and to this end, each species dealt with here is described by its *specimens* and illustrated with *individuals* rather than by generalized diagrams which may obscure finer differences. It is hoped that by the end of this work an accurate picture will emerge, demonstrating the variabilities and limitations of each species, providing higher taxonomists with detailed data, and ultimately adding to our knowledge of the tropical marine environment.

MATERIALS AND METHODS

Much of the material was collected by the author whilst the rest was sent by various individuals and institutions for identification over the last ten years. The specimens are preserved in 5% formaldehyde or 70% alcohol; many are accompanied by colour slides and/or collecting notes. Descriptions of external morphology are based on individual specimens unless stated otherwise. Descriptions of the digestive system were effected after a circular, dorsal incision enabled removal of the notum, and camera lucida drawings were prepared. Figures in this work are of indentifiable specimens, labelled as such in the legends. The specimens denoted by a capital letter in the "Material examined" sections are those which have been dissected. The abbreviations in parentheses after specimen details are of the source of the specimen: BMNH = The Natural History Museum (London), BP = Bernard Picton (Trinity College, Dublin), HD = Helmut Debelius (IKAN, Frankfurt), KRJ = Kathe Jensen (Zoological Museum, University of Copenhagen), MNHN = Museum National d'Histoire Naturelle (Paris), PK = Pam Kemp (U.K.), RBE = Rumphius Biohistorical Expedition (Leiden Museum), RC-V = Riccardo Cattaneo-Vietti (University of Genoa), SH = Samantha Harwood (Maldives Scuba Tours, U.K.), TP = Thomas Paulus

(Frankfurt), WAM = Western Australian Museum. Non-museum material listed has been despositced at the Natural History Museum (London); the Red Sea specimens can be found under accession number 2338 and the Indo-Pacific specimens under accession number 2350.

The synonymies listed for each species are only those evaluated by the author; no attempt has been made to reallocate Brunkhorst's (1993) synonymies except where relevant species are described and discussed.

SYSTEMATIC ACCOUNTS

Phyllidia ocellata Cuvier 1804

Figs. 1A–G, 4A; table 1

Synonymy:
Phyllidia ocellata Cuvier 1804: 267, fig. 7 ("Mer dęs Indes"); Gray 1857: 216, t. 312, fig. 8 (direct copy of Cuvier's figure).
Phyllidia carinata Eliot 1910: 435, pl. 25, figs. 8, 9, 12. (Seychelles).
Phyllidia japonica: Lim and Chou 1970: 134, pl. 16C (Singapore).

Material examined:
a. 27 × 24 mm preserved, curled; Bay of Tulamben, Bali, Indonesia; 3–20 m depth; November 1990 (HD).
B. 33 × 23 mm preserved, curled; Bay of Tulamben, Bali, Indonesia; 3–20 m depth; November 1990 (HD).
C. 30 × 18 mm preserved, curled; Bay of Tulamben, Bali, Indonesia; 3–20 m depth; November 1990 (HD).
D. 27 × 13 mm preserved; Manado, North Sulawesi, Indonesia; 5–15 m depth; November 1990 (HD).
E. 31 × 20 mm preserved; St. 18, Laha, Ambon, Indonesia; 15 m depth; 24 November 1990 (RBE).
f. 9 × 5 mm preserved; St. 18, Laha, Ambon, Indonesia; 8 m depth; 24 November 1990 (RBE).
g. 28 × 20 mm preserved, slightly curled; St. 18, Laha, Ambon, Indonesia; 6 m depth; 19 November 1990 (RBE).

Description: These specimens are virtually identical externally to those described and illustrated by Cuvier (1804) from 'Mer des Indes'. They bear a median crest of white tubercles, five to seven large ones and fewer smaller ones, and five black rings edged with a fine white line, each surrounding a large white tubercle (figs. 1A, B, C). There is a transverse row of five smaller orange tubercles just behind the rhinophores; only in specimen g were there four. The ground colour is orange and both the large and small tubercles are white. The tubercles are rounded and constricted at their bases to produce a mushroom shape. The rhinophores are located posterior to the anterior black ring. They issue from yellow-orange sheaths, which are distinctly raised; their bases are translucent, the clavii a shade deeper than the body colour (fig. 1D). The anus is located on the midline, and there is a small rim to the opening; the rim of the anal papilla is white. Ventrally, the sole of the foot is pale grey with a very much lighter edge. Anteriorly, it is deeply divided, even in the juvenile specimen (f; fig. 4A), and the oral tentacles are triangular with the lateral grooves distinctly visible (fig. 1E).

Internally (figs. 1B, C, F), the pharyngeal bulb is asymmetrical with very strong muscles

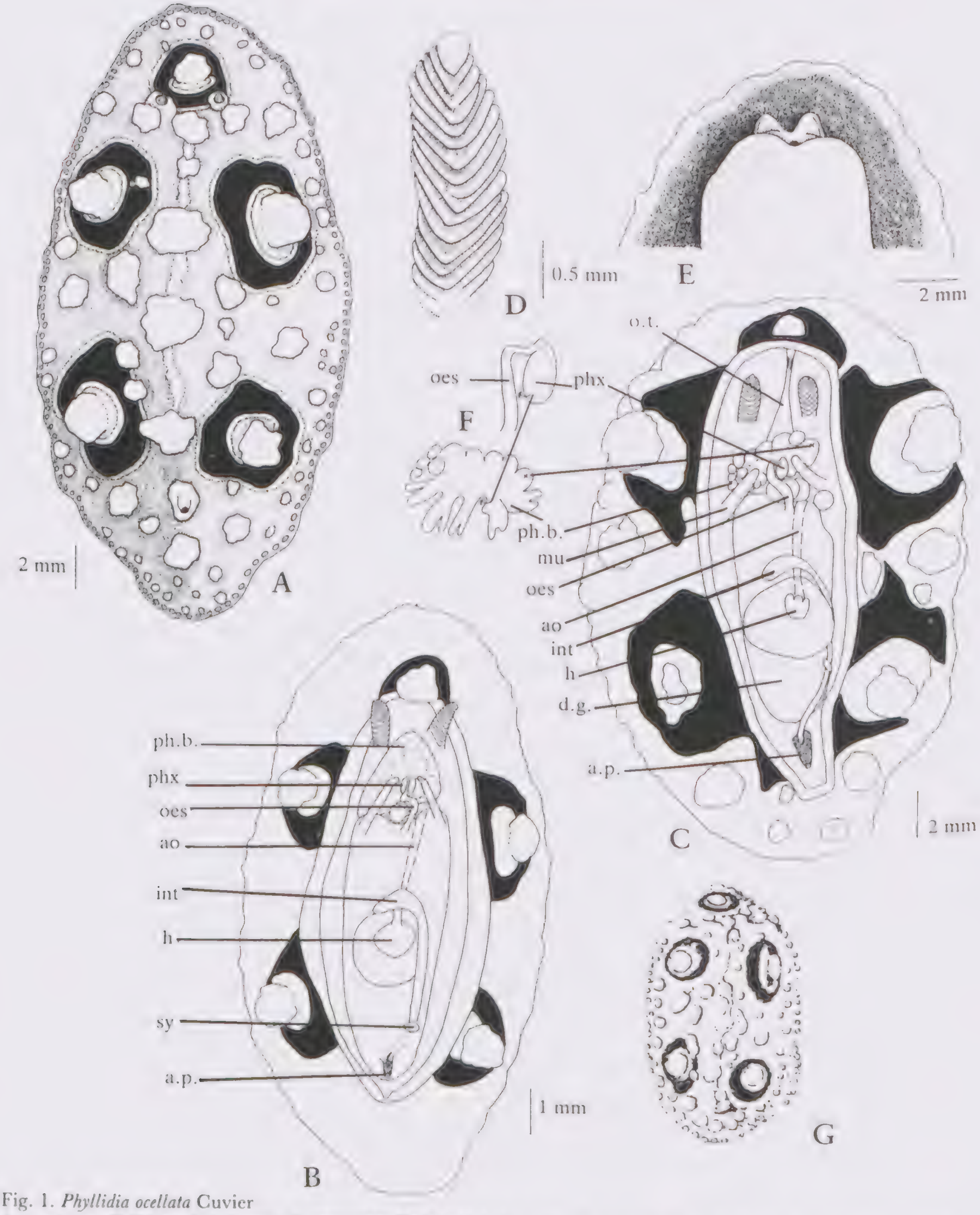


Fig. 1. *Phyllidia ocellata* Cuvier
A. specimen D (Manado): dorsal; B. specimen D: dorsal + digestive morphology; C. specimen E (Ambon): dorsal + digestive morphology; D. specimen D: rhinophore; E. specimen D: foot, mouth + oral tentacles; F. specimen E: magnification of ph.b. with phx and oes displaced; G. photocopy of Cuvier's (1904) drawing
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

inserting medially either side of the pharynx as in *Phyllidia undula (q.v.)*. The bulb is not sectioned as in *P. undula* and *P. multituberculata (q.v.)*, but lobed similarly to the bulb in species of *Fryeria (q.v.)*. The pharynx is swollen and bent back on itself, inserting into the pharyngeal bulb on the bulb's posterior face (fig. 1F). It narrows abruptly before passing through the nerve ring and has one kink in it before descending to the digestive gland. The aorta is edged in black, running down the digestive gland to the pericardium. The intestine originates at the halfway mark, also edged in black, and can be followed along the right side of the digestive gland to the syrinx. It then passes underneath the digestive gland and reappears as a black anal tube with a white rim. The pericardium is small.

Remarks: Cuvier's account of the external morphology of *P. ocellata* is identical to the specimen illustrated here, even with the five transversely arranged tubercles behind the rhinophores. He gave no account of internal anatomy or ventral characteristics. Brunckhorst (1993) synonymized all black, white, and orange, ringed and patched forms under the name *P. ocellata* Cuvier and designated a lectotype, stating there "there are no anatomical differences" between the different 'species'. However, the accompanying descriptions and drawings show that there are considerable differences in both external *and* internal characters between species, each of which shows little variation and no overlap with its most similar counterpart (see table 1). The records of true *P. ocellata* are few; a number of specimens are referred to *P. multituberculata* and *P. japonica*.

Phyllidia multituberculata Boettger 1918

Figs. 2A–E, 3A–G, 4B; table 1

Synonymy:
Phyllidia multituberculata Boettger 1918:129, taf. 8, figs. 4a-c (Aru Islands); Yonow & Hayward 1991: 21, figs. 10f, 13c (Mauritius).
Phyllidia baccata Pruvot-Fol 1957: 111, figs. 13–21, pl. 1 figs. I, II (Mauritius).
Phyllidia ocellata Edmunds 1972: 77, fig. 2 (Seychelles).

Material examined:
A. HOLOTYPE: *P. multituberculata*: Aru Island, Pulu Bambu. (leg. H. Merton, 3 April 1908). Senckenberg Museum, Frankfurt, reg. no. 1514. 48 × 29 mm preserved, well relaxed, flexible.
B. 20 × 10 mm; Lilot, Seychelles; 15 m depth on algal-encrusted rock; 26 April 1992 (PK).
C. 31 × 11 mm; Aquarium, Grand Baie, Mauritius; 13 m depth; 28 February 1990 (Yonow & Hayward 1991, BMNH acc. no. 2350).
d. 29 × 19 mm preserved; North-west bay, Mahé, Seychelles; 26.IV.38 (BMNH reg. no. 1960.1344, Winckworth collection, acc. no. 1838).
E. Syntype: *P. baccata*: 33 × 19 mm preserved, figured by Pruvot-Fol 1957, Mauritius (BMNH 1887.6.7.12–14).
f. Syntype: *P. baccata*: 12 × 8 mm preserved, Mauritius (BMNH 1887.6.7.12–14).
g. Syntype: *P. baccata*: 27 × 17 mm preserved, Mauritius (BMNH 1888.1.9.93–94).

Description: The oval body was bright orange in specimen b with nearly symmetrically arranged black patches, four on the left and three on the right, each bordered by white (fig. 2A). Additionally, anteriorly there is a crescent where another pair have merged. The black areas are tuberculate, but not the white bands surrounding them; in life the white surrounds were contiguous. There are small black flecks around the periphery. The largest tubercles are located along the midline and are joined to each other by a smooth crest. The tubercles are also smooth, unlike those of *P. ocellata (q.v.)*. The rhinophores were long and straight with a terminal blob (fig. 2B).

Ventrally, the foot is deeply notched anteriorly and the conical oral tentacles are fat, with

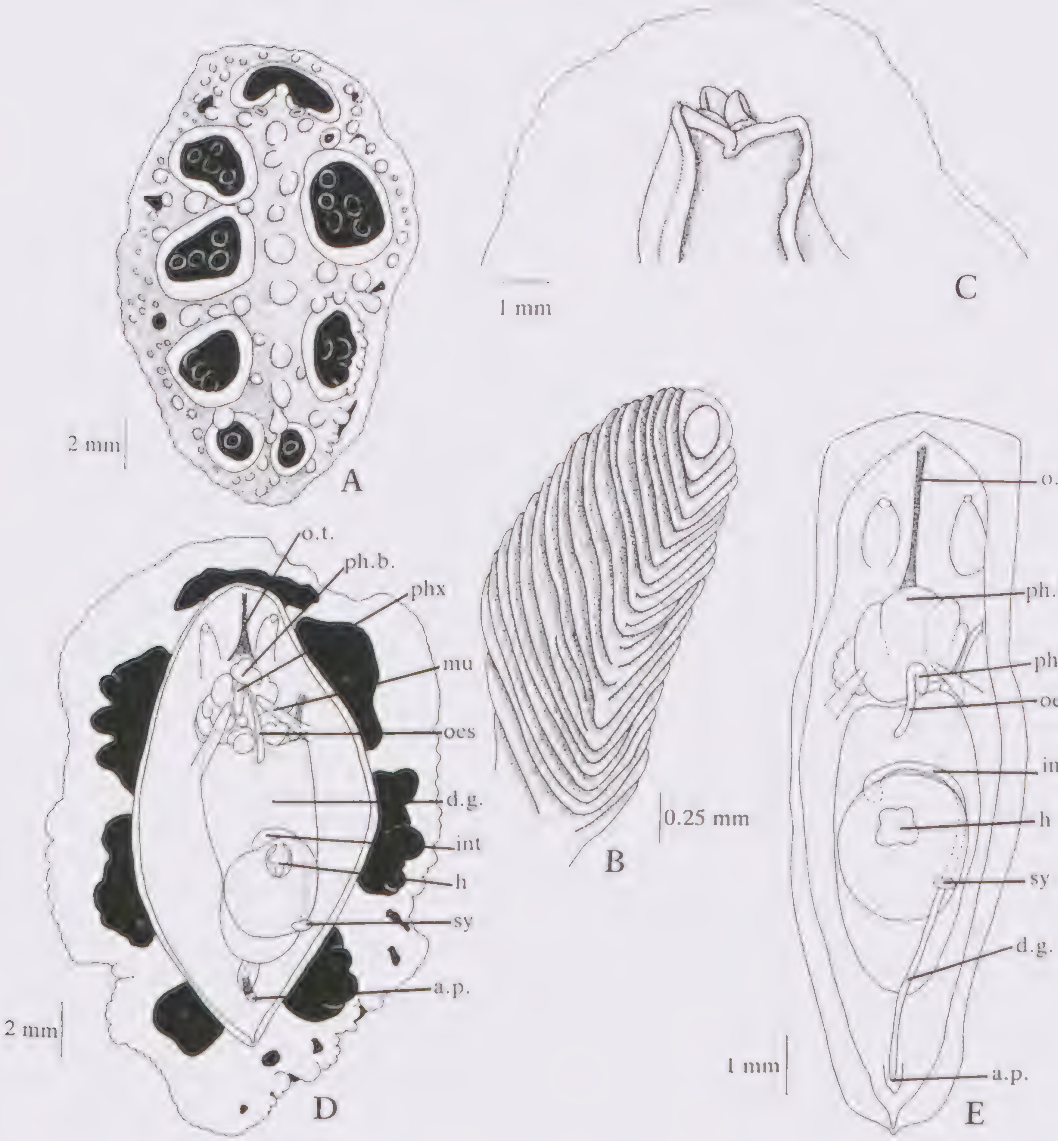


Fig. 2. *Phyllidia multituberculata* Boettger
A. specimen B (Seychelles): dorsal; B. specimen C (Mauritius): rhinophore; C. specimen B: foot + oral tentacles; D. specimen C: dorsal + digestive morphology; E. specimen B: digestive morphology
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

a slit along the outer sides (fig. 2C). The foot is dark grey in the larger specimens. The Mauritius specimen (C) has been described previously (Yonow & Hayward 1991); the BMNH specimen (d) is identical to the above, the four black patches on the left and three on

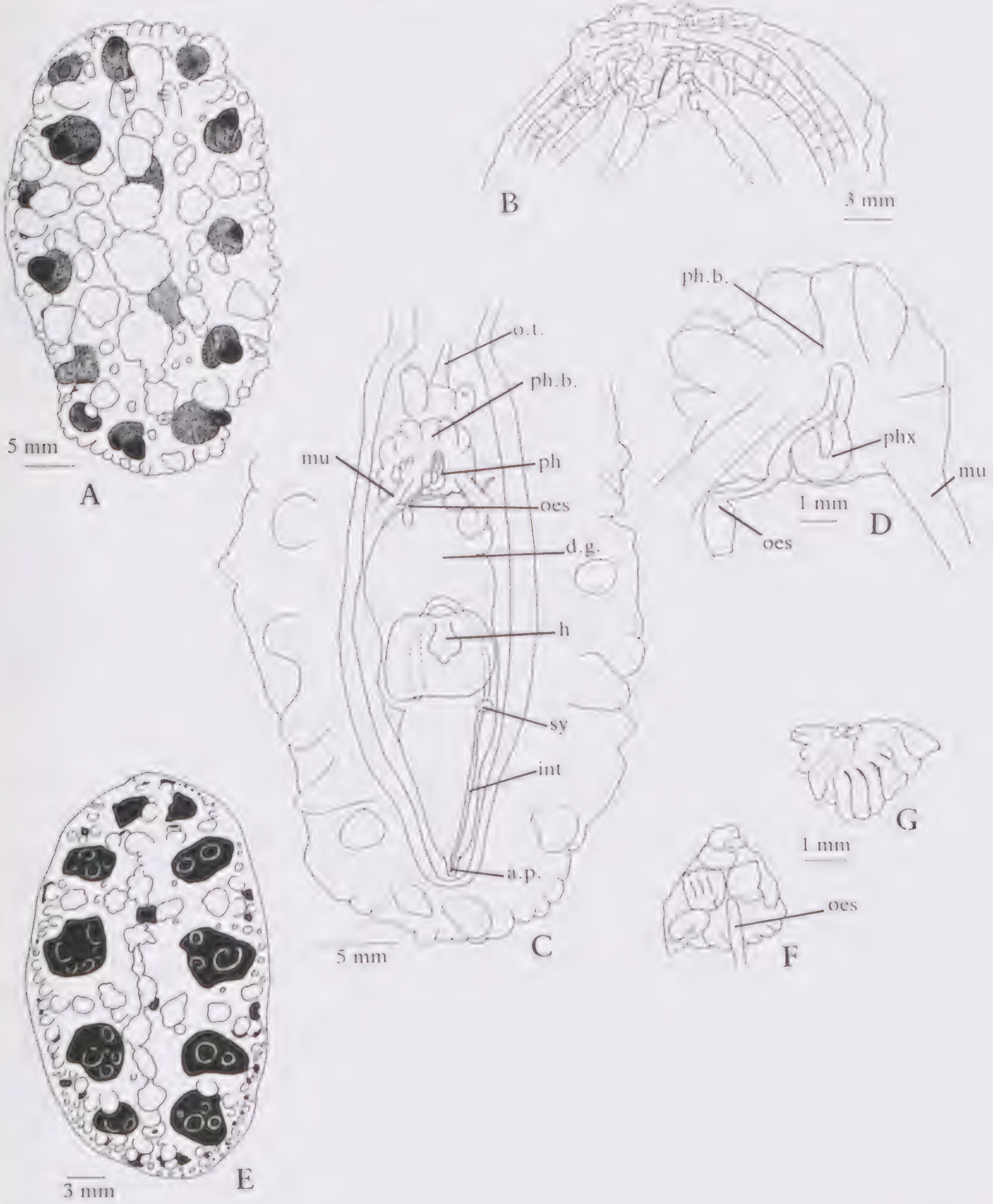


Fig. 3. *Phyllidia multituberculata* Boettger

A. Holotype: specimen A (Aru Island): dorsal; B. Holotype: foot + oral tentacles; C. Holotype: digestive morphology; D. Holotype: magnification of ph.b., phx + oes; E. Syntype *P. baccata*: specimen E (Mauritius): dorsal; F. Syntype: dorsal view of ph.b. + oes; G. Syntype: ventro-posterior view of ph.b.

ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla the right; the first two on the left are connected near the midline. Anteriorly, the additional pair are connected. The syntypes of *P. baccata* were examined and proved identical to the holotype and additional material presented here (figs. 3E–G). The smallest specimen (f: 12 mm) is quite distinct from juveniles of equivalent size of *P. ocellata* (9 mm) and *P. undula* (11 mm); see fig. 4.

Internally the black oral tube is long and thin-walled, leading to an asymmetrical pharyngeal bulb, comprising five or six parts. The muscles insert onto the bulb dorsally, very close to the pharynx in specimen b, and to the grey cavity lining. The pharynx is thickened, inserting posteriorly on the bulb, looping once; the oesophagus is long and thin, and descends onto the digestive gland. The intestine originates in the anterior one third to half of the digestive gland and can be traced its full length to the anus in some specimens; posterior to the white syrinx it becomes bright pink in specimen b (the most recently collected). In specimens C and E the anal papilla is streaked with or solidly black. The ventricle is situated below the origin of the intestine above the centre of the digestive gland and the sac expands all around it, overlying the origin of the intestine and its first half as well as the syrinx.

Remarks: This species was first redescribed in its correct taxon in 1991 from Mauritius (Yonow and Hayward 1991); the specimens from the Seychelles clearly belong to this species. The additional information on internal anatomy adds to that of Pruvot-Fol (1957) and Edmunds (1972), especially as it is based on recently collected material. Pruvot-Fol (1957) made no mention of the black oral tube, although stated that the anal papilla was black. The holotype (fig. 3A) was kindly sent by Dr. R. Janssen (Senckenberg Museum), with permission to dissect to establish its identity. Camera lucida drawings were prepared of its dorsal and ventral surfaces before dissection, effected by an oval dorsal incision to remove the central area (fig. 3C). The recent material compares favourably with the holotype, which is quite clearly different from the other species in the colour group.

Phyllidia undula Yonow 1986
Figs. 4C, 5A–F; table 1

Synonymy:
Phyllidia ocellata undula Yonow 1986: 1411, figs. 5, 12a, 12b (Red Sea); Yonow 1988: 146, pl. 5 (Red Sea).
Phyllidia undula Yonow 1990: 297 (Red Sea).

Material examined:
A. 25 × 18 mm preserved, curled; Dahab, Sinai, Red Sea; November 1990 (Hausmann).
b. HOLOTYPE: 40 × 23 mm; Tongue Island, Red Sea; 19 June 1983; 15 m depth (Yonow 1986; BMNH 1985.208/1).
c. Paratype: 18 × 11 mm; Tongue Island, Red Sea; 19 June 1983; 20 m depth (Yonow 1986; BMNH 1985.208/2).
D. 44 × 25 mm; Tongue Island, Red Sea; 19 June 1983; 7 m depth (Yonow 1986; BMNH acc. no. 2338).
E. 42 × 24 mm preserved; Mamlach, Sinai, Red Sea; May 1980; 10–15 m depth (BP, Yonow 1986, BMNH acc. no. 2338).
F. 32 × 15 mm preserved; Marsa Bareka, Sinai, Red Sea; May 1980; 10–15 m depth (BP, Yonow 1986, BMNH acc. no. 2338).
g. 11 × 7 mm preserved; Harvey Reef, N. Towartit, Port Sudan (BMNH, J. D. Taylor 1978).

Description: The specimens from Dahab and Harvey Reef are almost identical to the types figured by Yonow (1986: figs. 5A and 12A, B) (fig. 5A). The only additional observations I can make are to add more detail to the ventral head and tentacles (fig. 5B). The oral

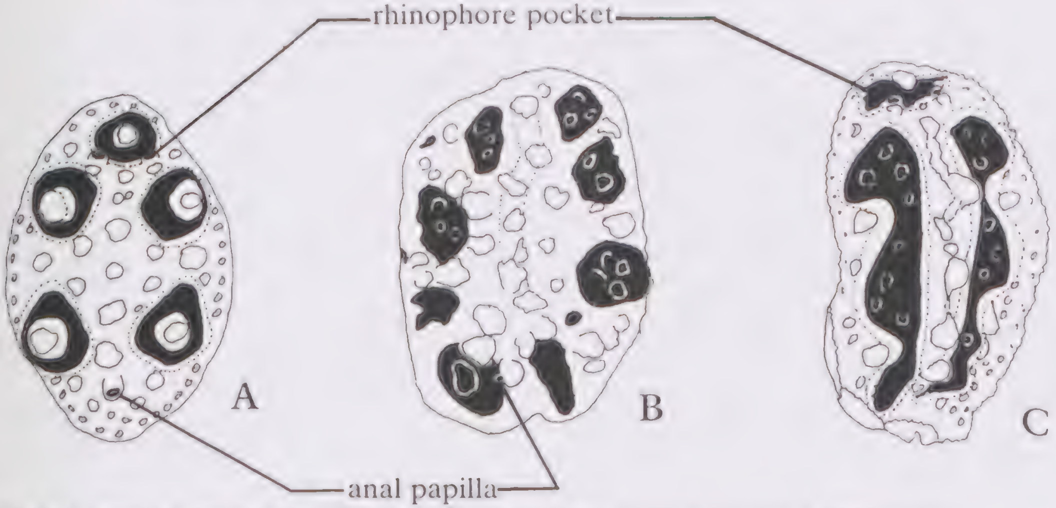
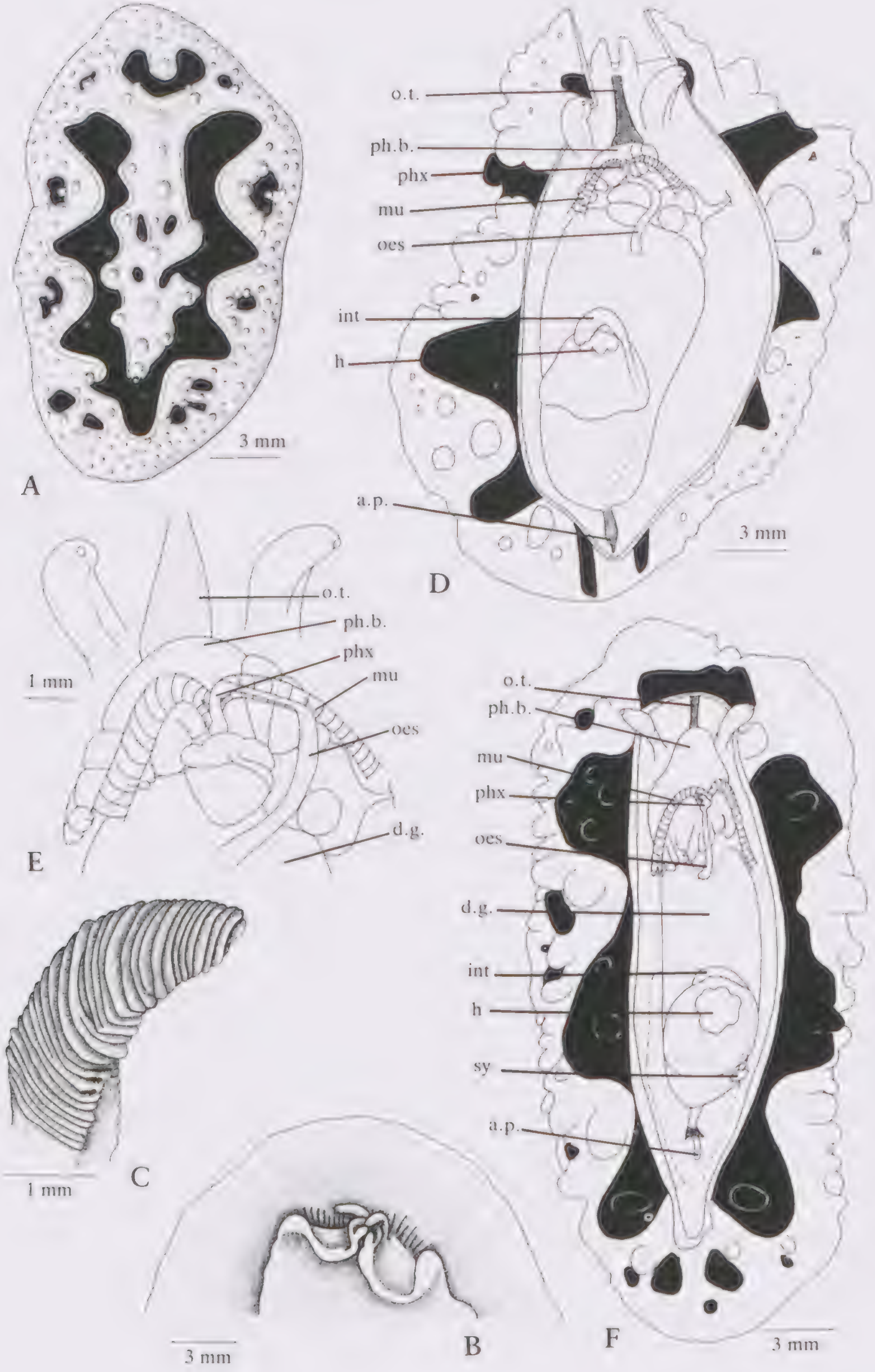


Fig. 4. A. juvenile *P. ocellata* 9 mm; B. juvenile *P. multituberculata* 12 mm; C. juvenile *P. undula* 11 mm

tentacles are longer than in Yonow (1986; fig. 5B) tapered, parallel-sided medially, and grooved laterally. The head is clearly visible as two lips meeting medially, as shown, and not extending the width of the foot. The foot is deeply concave to notched anteriorly. The juvenile specimen (g) is identical dorsally and ventrally to the adults; the black pattern is clearly present as undulations in juveniles and not rings, indicating ontogenetic differences between *P. undula*, *P. ocellata*, and *P. multituberculata* (*q.v.*; fig. 4). The rhinophores are bright orange and densely lamellate (fig. 5C).

Internally, the oral tube is black, leading into an assymmetrical pharyngeal bulb, much deeper on the left side. The bulb is divided into six to eight swollen sections in specimens A and D (figs. 5D, E). In specimen D there are subdivisions along the posterior edge, reminiscent of those in the genus *Fryeria*. The bulbs of specimens E and F are less obviously divided but the subdivisions of the posterior edge are more prominent (fig. 5F). The muscles attach dorsally to a black cavity lining, and into the middle of the pharyngeal bulb, where they divide into two. They are very particular, glistening white with transverse bands, and very long, attaching more than half way along the body wall. The thick pharynx exits medially, between the two muscles. It comes up, turns down at an abrupt swelling, and narrows for a short distance, passing through the nerve ring, and thickens for the rest of its length, inserting into the digestive gland dorsally. The intestine originates approximately half-way along the digestive gland, and is covered by a large pericardium. In specimens A and F the sheath around the anal papilla is black, while in specimen E the papilla itself is black. Specimen D reacted with the formaldehyde and the posterior area is crumbly and broken up.

Remarks: *P. undula* clearly belongs to the "*ocellata*" colour group in which specimens are orange or yellow. I still maintain the same species groupings as in Yonow (1986). With the additional material which has been put at my disposal, I can now assign group 1 to *P. ocellata* Cuvier (this study), group 2 to *P. multituberculata* Boettger (Yonow & Hayward 1991 and this study), group 3 to *P. japonica* Baba (this study), and group 5 to *P. undula* Yonow (Yonow 1986 and this study). It is unfortunate that Brunckhorst (1993) did not dissect the Red Sea material he synonymized with *P. ocellata*. I cannot agree with his opinion that these are all one species, as can be shown by camera lucida drawings of the external and internal characteristics, which clearly differentiate between the four species (see table 1). In addition,


A
3 mm
o.t.
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E
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C
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h
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3 mm
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F
3 mm

the constant external morphology of the juveniles indicates that the species are different. To date, I have not found '*undula*' morphological characteristics from anywhere other than the Red Sea. *P. undula* and *P. multituberculata* are more similar to each other, while *P. japonica* and *P. ocellata* show similarities. *P. undula* has a longer oesophagus than *P. multituberculata*, and a very asymmetrical pharyngeal bulb. Both species have black oral tubes, while *P. multituberculata* has a bright red pink intestine (in the freshest specimens) which is clearly visible along its complete length, unlike *P. undula*, in which it lies within the digestive gland for its distal half. The pharyngeal muscles of *P. undula* are also very distinctive. There are still a number of species belonging to this colour group from the Pacific realm, which will be covered in subsequent papers as more material becomes available.

Phyllidia japonica Baba 1937

Figs. 6A–F; table 1

Synonymy:

Phyllidia tuberculata Baba 1930: 117; pl. IV, figs. 1a–d (Japan).

Phyllidia japonica Baba 1937 (nom. nov. for *P. tuberculata*): 310; not Baba 1949: 57, 157, pl. 29 fig. 108 (Japan).

Phyllidia ocellata: Baba & Hamatani 1975: 176, fig. 4 (Japan); Willian & Coleman 1984: 42, fig. 130 (Australia).

Baba pers. comm. 1984–1987: numerous photos and drawings of external and internal morphology including holotype (Japan).

Material examined:

A. 38 × 15 mm preserved; north west of Orpheus Island, GBR, Australia; 10 m depth; 8 November 1986 (RC–V).

B. 32 × 16 mm preserved; st. 27, Hutumuri, Ambon; 3 m depth; 27 November 1990 (RBE).

Description: The Australian specimen (a) was yellow, with four paired black rings/patches surrounding a yellow tubercle and edged in white; the first and last pairs have coalesced (figs. 6A, B). The Indonesian specimen (b) has three paired black rings/patches surrounding an orange tubercle, each edged in white. Anteriorly, on the left side, is another and there are additional patches of black posteriorly and along the midline. The tubercles on the midline are irregular in the preserved material, mushroom-shaped and touching. Ventrally, the foot of specimen a is much greyer than that of specimen b. Both have a notched foot, distinct head, and short fat oral tentacles with grooves (fig. 6C); the Australian specimen is damaged and has an extra piece of foot/mouth on its left side (fig. 6D).

Internally, the digestive anatomy is very distinctive (figs. 6B, F). The oral tube is unmarked, leading to a pharyngeal bulb which is very elongated and assymmetrical with many protruding glands around its posterior margin. The pharynx is very large and swollen, bent over itself, and inserts into the posterior face of the bulb. Its first half is opaque white, the distal portion black, and leads into a long, thin, straight oesophagus. The intestine is dark, as is the aorta, and the pericardium is very large. The anal papilla is swollen with black markings on its base and part of its tube, and is surrounded by a sheath which is also edged in black.

←

Fig. 5. *Phyllidia undula* Yonow (Red Sea)

A. Holotype: specimen B: dorsal; B. specimen E: foot + oral tentacles; C. specimen A: rhinophore; D. specimen A: dorsal + digestive morphology; E. specimen A: magnification of o.t., ph.b., phx + oes; F. specimen E: dorsal + digestive morphology

ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

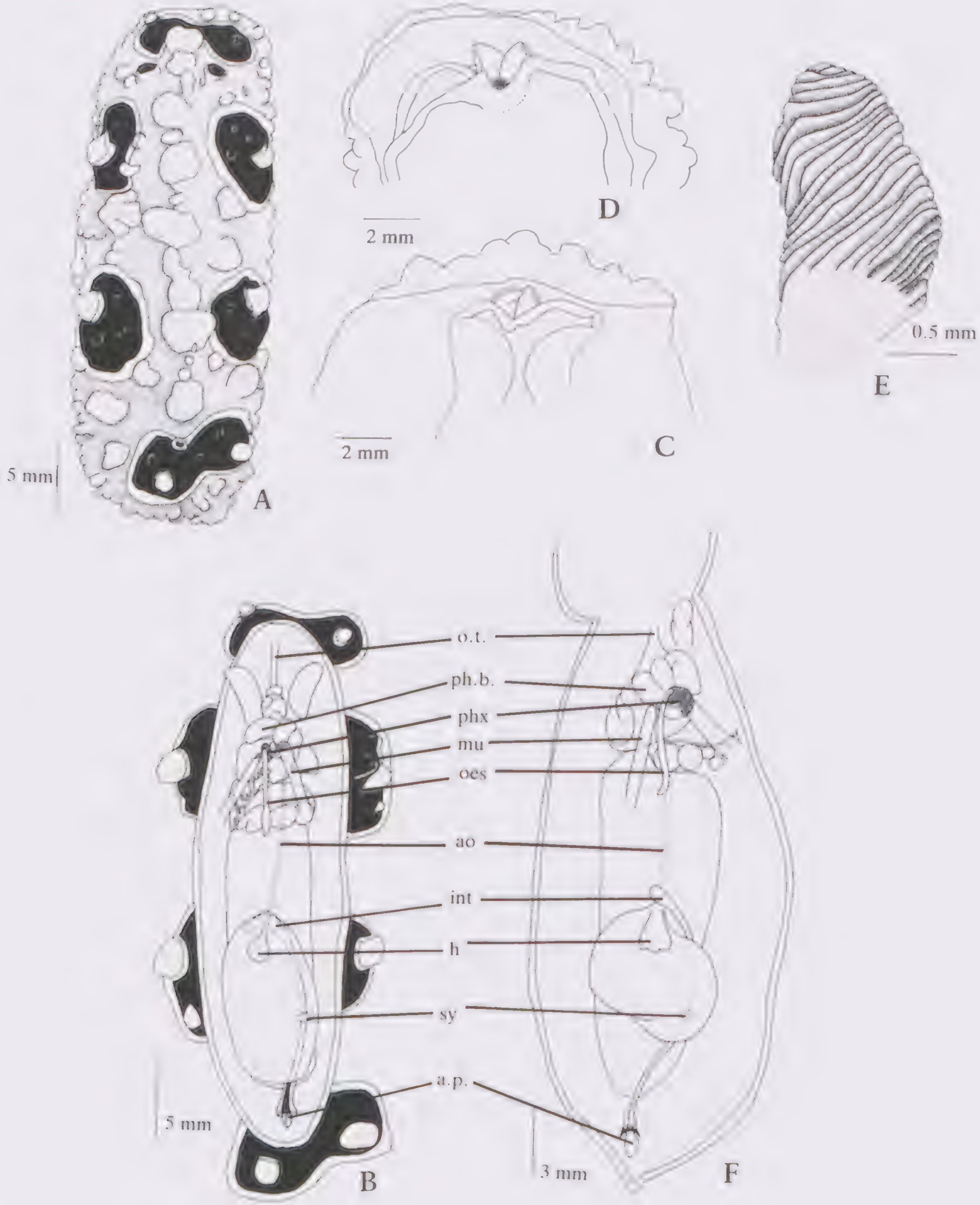


Fig. 6. *Phyllidia japonica* Baba

A. specimen A (Orpheus Island): dorsal; B. specimen A: digestive morphology; C. specimen B (Ambon): foot + oral tentacles; D. specimen A: foot + oral tentacles; E. specimen B: rhinophore; F. specimen B: digestive morphology

ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

Remarks: Seven specimens are included in a set of notes and drawings from Baba, of which two have been dissected; they all come from the waters around Japan. All have four or five pairs of rings except for two specimens, the first with three on the left and four on the right, and the second with four on the left and five on the right. All those measured were between 40 and 50 mm alive. *P. japonica* has a tendency to be longer and narrower than the other species in the complex, both when alive and when it is preserved. Internally, the very large, partially black pharynx and the straight oesophagus serve to distinguish it from *P. ocellata*, to which it is most similar. Baba's drawings and his published figure (1930: pl IV, fig. 1d, as *P. tuberculata*), with the pharyngeal bulb glands and a thick doubled-up pharynx, are in agreement with the camera lucida drawings presented here. The genital system is also in accordance, distinctive in its large size compared with other species in this colour group.

TABLE 1

Comparative differences between four species belonging to the *Phyllidia ocellata* colour complex

CHARACTERS	*P. ocellata*	*P. multituberculata*	*P. undula*	*P. japonica*
median crest joined?	white tubercles thin ridge	white tubercles smooth crest	orange tubercles no, separate	yellow/orange tub confluent
black marks	5 smooth rings	5 tuberculate patches	tuberculate undulations	tuberculate patches
tubercles	mushroom, irregular	round, smooth	round, smooth	mushroom, irregular
body shape ratio w:l	oval 1:1·4	oval 1:1·7	oval 1:1.8	elongated 1:2·5
anterior foot	divided	notched	concave-notched	notched
oral tube	colorless	black	black	colorless
pharyngeal bulb	asymmetrical	segmented	segmented	asymmetrical
muscles	bundles	bundles	glistening, transverse bands	bundles
pharynx	swollen	swollen	thick with abrupt swelling	swollen, ½ black ½ white
oesophagus	2 bends	straight	straight	straight
anal papilla	black	black + white	–	black markings
sheath	–	–	black	black
distribution	West Pacific	Indian Ocean	Red Sea	West Pacific

Phyllidia arabica Ehrenberg 1831

Figs. 7A–F, 8A–C; table 2

Synonymy:

P. arabica: Yonow 1986: 1403, figs. 10A,B,C (Red Sea); Yonow 1988; 143, pl. 1 (Red Sea); Yonow & Hayward 1991: fig. 12F *only* (Mauritius).

P. varicosa: Eliot 1904: 281 (East Africa); Eliot 1906; 562 (part) (Maldives); Baba 1936: 42–43, fig. 25 (Okinawa, Japan); Pruvot-Fol 1956: 61 (no locality); Lim & Chou 1970: 135, pl. 16B (Singapore); Edmunds 1971: 388, fig. 23 (Tanzania); Edmunds 1972: 75 (Seychelles); Rao, Sivadas & Kumary 1974: 119, figs. 2a, b (Laccadives); Baba & Hamatani 1975: 174, fig. 1 (Japan); Wu & Romig 1982: 149, figs. 1, 2 (Taiwan); Soliman 1986: 225, figs. 1–4 (Red Sea); Yonow 1984: 227, figs. 7C, 8C, D, E (Sri Lanka); Brunckhorst 1993: fig. 23, pl. 1C, D (Réunion and Thailand).

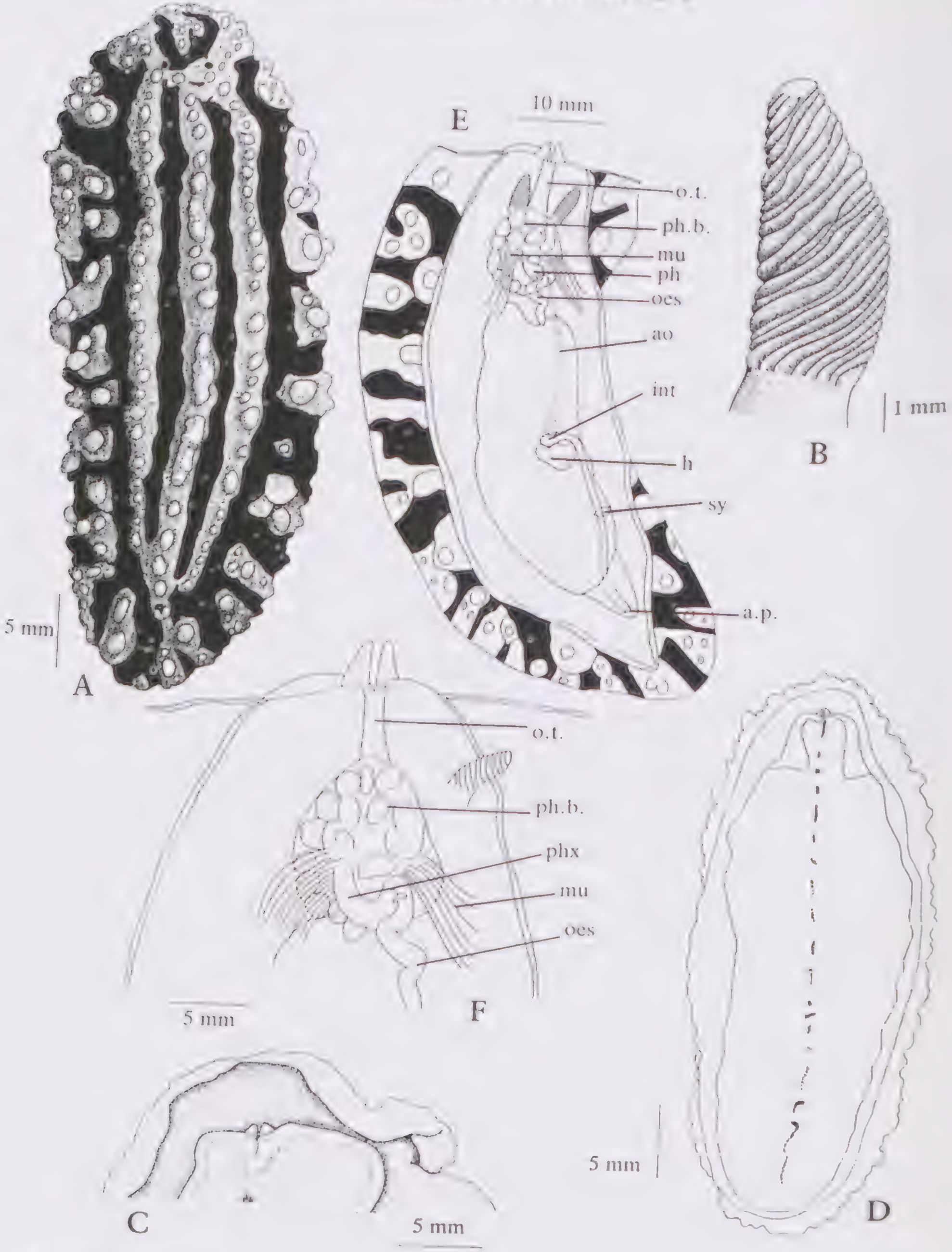


Fig. 7. *Phyllidia arabica* Ehrenberg
A. specimen R (?Sri Lanka): dorsal; B. specimen A (Maldives): rhinophore; C. specimen C (Red Sea): head + oral tentacles; D. specimen T (?Sri Lanka): sole of the foot; E. specimen A: dorsal + digestive morphology; F. specimen A: magnification of or.t., ph.b., phx + oes
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

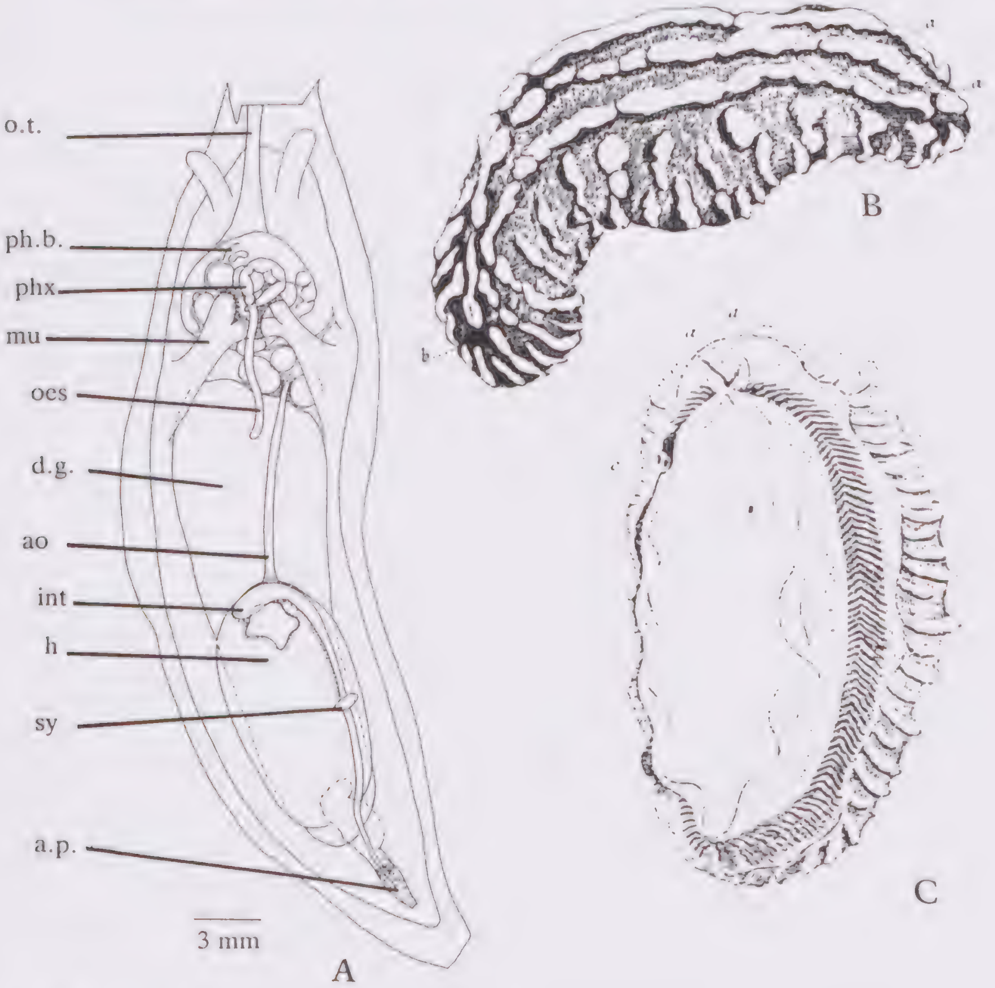


Fig. 8. *Phyllidida arabica* Ehrenberg

A. specimen B (Maldives): digestive morphology; B. photocopy of Cuvier's (1804) drawing, dorsal; C. photocopy of Cuvier's (1804) drawing, ventral

ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

P. trilineata: Quoy & Gaimard 1824: 419, pl. 87, figs. 7–10 (Timor).
P. fasciolata: Bergh 1869; 507 (Madagascar); Eliot 1904: 281 (East Africa).
P. honloni: Risbec 1956: 22, figs. 71–75, 79–81 (Viet Nam); Lim & Chou 1970: 134, pl. 17b (Singapore); Lim 1983: 152, pl. 1, fig. 6 (China).
Baba 1984–1987: pers. comm. photos and unpublished manuscripts of external morphologies (Japan).

Material examined:
A. 105 × 30 mm; Kiadhu Tila, Felidhoo Atoll, Maldives; 25 m depth: 13 January 1991.
B. 62 × 27 mm; Boduhithi Channel, North Male Atoll, Maldives; 21.5 m depth: 11 May 1990.

C. 58 × 27 mm preserved; TQ 7, Sanganeb, Red Sea; 8 m depth 4 April 1991 (TP).
D. 30 × 12 mm preserved; Phuket, Thailand; February 1982 (Copenhagen Museum).
f. 70 × 28 mm; Dhagethi Tila, Ari Atoll, Maldives; 17 m depth; 16 January 1991.
g. 50 × 20 mm; as f above.
h. 25 × 8 mm; Madiwaru, Ari Atoll, Maldives; 25 m depth; 14 May 1990.
i. 36 × 13 mm; as h above.
j. 70 × 40 mm; Bathala Faru, Ari Atoll, Maldives; 15 m depth; 17 January 1991.
k. 50 mm in length; as j above.
l. 8 × 3 mm; Maaya Tila, Ari Atoll, Maldives; 10 m depth; 15 May 1990.
m. 37 × 22 mm preserved; Gangehi lagoon, Ari Atoll, Maldives; 1–5 m depth; February 1988 (RC–V).
n. 48 × 30 mm preserved; TQ 4, Sanganeb, Red Sea; 8 m depth; 26 March 1991 (TP).
o. three specimens 30–50 mm preserved, curled; Gangehi lagoon, Ari Atoll, Maldives; 0–5 m depth; August 1990 (RC-V).
p. 65 × 23 mm; ?Sri Lanka (via tropical fish importers); August 1990.
q. 60 × 17 mm; as p above.
r. 50 × 19 mm; as p above.
s. 47 × 16 mm; as p above.
t. 36 × 14 mm; as p above.
u. 18 × 8 mm preserved; Maldives Islands; January–May 1991 (SH).
v. 18 × 7 mm preserved; as u above.
w. 15 × 7 mm preserved; as u above.
x. two specimens 50 and 55 mm in length preserved; Maldives (MNHN).
y. 55 × 25 mm; Willy's Rock, Seychelles; 12 m depth on sand; 23 March 1992 (PK).
z. 20 × 13 mm preserved, slightly curled; Passe Midi, Aldabra, Indian Ocean; 0.5 m beneath coral on hydroids; 10 July 1969 (Taylor, BMNH acc. no. 2222).
AA. 40 × 27 mm preserved, bent and curled; West Channels, Aldabra, Indian Ocean; 25 August 1967 (Taylor, BMNH acc. no. 2222).
BB. 67 × 38 mm preserved; East Channel, Aldabra, Indian Ocean; 9.18.69 (*sic*) (Taylor, BMNH acc. no. 2222).
cc. 35 × 18 mm preserved, bent; Red Sea (E. Rüppell, Senckenberg Museum 219.174).
dd. 30 × 17 mm preserved, bent and curled (MNHN, no label).
ee. 49 × 30 mm preserved, bent and curled (MNHN, no label).
ff. 45 × 35 mm preserved, bent; BMNH (no label, relabelled BMNH/NY/1).
gg. 32 × 22 mm preserved, slightly curled; Flying Fish Cove, Christmas Island, Indian Ocean (BMNH 99.5.26.11).
hh. 43 × 19 mm preserved: *P. trilineata* Quoy & Gaimard expedition 'Freycinet' 1820 (BMNH 1954.7.24.181).
ii. 60 × 28 mm preserved, squashed and curled; Mozambique shore 'Alert' collection (BMNH 1882.12.6.339).
jj. 59 × 26 mm preserved; Zanzibar 1980, JD Robertson (BMNH Eliot 1904 (2): 281, A).
kk. 45 × 27 mm preserved, curled; Phoenix Bay, Port Blair, Andaman 25.iii.36 (BMNH 1960.1339; Winckworth 1838, RW1 p. 7).
ll. 43 × 18 mm preserved; data as for kk (BMNH 1960.1338).
mm. 53 × 23 mm preserved, curled; Aves Is., N. Andaman (BMNH 1960.1341;RW2 p. 41).
nn. 21 × 12 mm preserved; Aberdeen Rocks, Port Blair, Andaman, 7.iv.39 (BMNH 1960.1342; RW2 p. 46).
oo. 13 × 7 mm preserved, data as for nn; 20.ii.39 (BMNH 1960.1340; RW2 p. 12).
pp. 35 × 18 mm preserved; JS Gardiner 'Sealark', Solomon Is, Indian Ocean (BMNH Eliot 1910: 435).

qq. 47 × 27 mm preserved; Andaman Is, Indian Ocean, Dr. J. Anderson (BMNH 86.8.2.16–18).
rr. 85 × 55 mm preserved, folded; data as for qq.
ss. 63 × 35 mm preserved; data as for qq.
tt. 60 × 28 mm preserved; Zanzibar 1950, J. D. Robertson (BMNH 1955.12.20.3).
uu. 57 × 28 mm preserved; Cocos Is, Indian Ocean, Dr. F. Wood Jones (BMNH 1908.10.5.1).
vv. 20 × 8 mm; Amboina, Mr. Franks collection (BMNH 1858.6.25.49).
ww. 40 mm (36 × 17 mm preserved); Shimoniwith 2.17.7.70.CHA (T. E. Thompson collection, BMNH acc. no. 2364).
xx. MNHN 1491.E.34202–34205 Risbec (1956) *P. honloni* sp. nov., Viet Nam.
yy. MNHN 1496.E.345999 Risbec (1956) *P. honloni* sp. nov., Viet Nam.

Description: All these specimens fit perfectly the descriptions of *P. arabica* given by Yonow (1986) and *P. varicosa* of other authors listed in the synonymy (figs. 7A–D). Additional notes are as follows: the yellow pigment varies from orange-yellow to orange in the specimens seen by the author or accompanied by colour photographs. The black line in all specimens is broken into a series of dashes (fig. 7D). In the larger specimens seen alive by the author from the Indian Ocean and the Red Sea, the long oral tentacles are tipped with orange in life and this remains in some of the preserved material. In preservative the oral tentacles retain their large size and are usually triangular in shape and parallel-sided medially. Depending upon the preservative the head is sometimes visible behind them, or contracted at the base producing a bilaminate edge to the foot. The foot is always notched anteriorly or, rarely, deeply concave. The rhinophores are long and digitiform in life, with the lamellae numbering between 22 and 26 (fig. 7B).

Internally, the body cavity bears a translucent black lining. The long thin oral tube leads into a large solid pyramidal pharyngeal bulb. Dorsally it is covered in rounded nodules and ventrally it is flattened with a fringe of finger-like glands, the oral glands. The bulb is attached to the cavity lining by two strong muscles, one on each side. In specimen B, the muscles divide deep in the bulb (fig. 8A). Uppermost is a blood gland (variable in colour from white, grey, and brownish) overlying the nerve ring. The thick pharynx is short with two bends before reaching the nerve ring. It narrows slightly before entering the digestive gland anteriorly and dorsally. It is enclosed in a peritoneum which bears a longitudinal black band from the level of the nerve ring to the pericardium, the aorta. The intestine originates halfway and runs around the pericardium and down the right side, under the syrinx, and to the anus. In specimen B the anal papilla is black and the gonads yellow. The pharyngeal bulb of specimen BB is detached from the rest of the body and bears 12 glands around the posterior ventral edge; the oral tentacles still retain some orange. *P. trilineata* of Quoy & Gaimard (specimen hh) has a dashed line anteriorly, which is somewhat more continuous posteriorly, the oral tentacles are still yellow, and the foot is deeply notched.

Remarks: Brunckhorst (1993) concludes that *P. arabica* is a synonym of *P. varicosa* Lamarck and that all specimens have a black stripe on the sole of the foot. Most early authors were careful in their descriptions and figures of animals, and I have difficulty in believing that Cuvier would omit the black line in both his description *and* his perfectly clear drawings (see figs. 8B, C); that Quoy & Gaimard (1832) stated that not all specimens had black lines on the sole of the foot supports this theory. A species cannot be dismissed simply because it has not been found recently. I have yet to see a *P. arabica* which is so faded that the black on the dorsal and ventral surfaces disappears completely; a bottle containing two specimens in the MNHN (Paris) with no labels contains two *P. arabica*; they both retain all the black on the dorsal surfaces, the larger has a very faded line on the sole and the smaller has a very distinct black line. Unfortunately, the situation is further complicated by the selection of a neotype with a black line on the sole (Brunckhorst 1993: 27). Until further specimens without a black line on the sole are found, the situation must remain unresolved.

Phyllidia alyta sp. nov.
Figs. 9A–G; table 2)

Synonymy:
P. arabica: Yonow & Hayward 1991: 18, figs. 11a, b only (*not* fig. 12f) (Mauritius).

Material examined:
A. 32 × 14 mm; Nakatcha Tila, North Male Atoll, Maldives; 20 m depth; 12 May 1990.
B. 25 × 10 mm; as A above.
C. 40 × 18 mm; Kandholudhu fringing reef, Ari Atoll, Maldives; 28 m depth; 15 May 1990.
d. 13 × 6 mm; Bodhu Fahlu, Ari Atoll, Maldives; 15 m depth; 19 January 1991 (SH).
e. Paratype: 20 × 10 mm preserved; Kandholudhu Tila, Ari Atoll, Maldives; 24 m depth, 17 January 1991.
f. HOLOTYPE: 25 × 11 mm preserved; collecting data as for e.
g. Paratype: 27 × 10 mm preserved; collecting data as for e.
h. 20 × 10 mm; Kunarvashi Tila, Felidhoo Atoll, Maldives; 22 m depth; 14 January 1991.
I. 20 × 9 mm; collecting data as for h.
J. 23 × 10 mm preserved; Kudhiboli Tila, Felidhoo Atoll, Maldives; 21 m depth; 15 January 1991 (SH).
k. 33 × 10 mm; Dhagethi Tila, Ari Atoll, Maldives; 24 m depth; 15 January 1991.
L. 38 × 16 mm; Pointe Vacos, Mauritius; 4 m depth; 25 October 1985 (as *P. arabica*, Yonow and Hayward 1991, BMNH acc. no. 2350).
M. 19 × 15 mm; Belle Mare Plage, Mauritius; 18–25 m depth; 27 February 1990 (as *P. arabica*, Yonow and Hayward 1991, BMNH acc. no. 2350).
n. 16 × 9 mm preserved; BMNH no label, relabelled BMNH/NY/1.

Description: This pretty species is characterized by four longitudinal black bands which rarely meet. One pair runs from behind the rhinophores to a short distance in front of the anus; this pair edge the median crest of tubercles which are almost always orange. These black lines are followed by a row of tubercles, which are rarely tipped with orange. These originate just posterior to the rhinophores with a tubercle and run down towards the anus, meeting with the median crest. The second pair of black lines are usually thicker than the first and run from the anterior edge of the posterior edge; at each end they usually bend outwards slightly. Also distinctive is the short black transverse band between the rhinophores; only in the Mauritius specimens does it just barely touch the central pair of black lines. The flattened edge of the mantle is marked by a row of medium-sized tubercles, followed by a band of tiny haphazardly-arranged pustules which are rarely interspersed with patches of black pigment (fig. 9A); the Mauritius specimens show an extreme form of this. The rhinophores are orange, with 18–20 lamellae (fig. 9B).

Ventrally, the foot is concave, not notched (*cf. P. arabica*), and the oral tentacles attached separately to the head, which is visible as bipartite (figs. 9C, D). The oral tentacles are grooved on their outer edges. A solid black line is present on the sole of the foot, which is always broken anteriorly into one of two patches but then continuous (*cf. P. arabica*). The edges of the gills are black.

Internally, the oral tube is thin-walled, and in one of the six specimens dissected (j) bore no black markings. In two specimens (a, c) black patches were present on either side (fig. 9E), and in the last three (b, l, m) were continuous over the dorsal surface of the tube (figs. 9F, G). The pharyngeal bulb is very convoluted, larger on the left side; on the right the space is taken up by the three relatively large bulbs of the reproductive system, always clearly

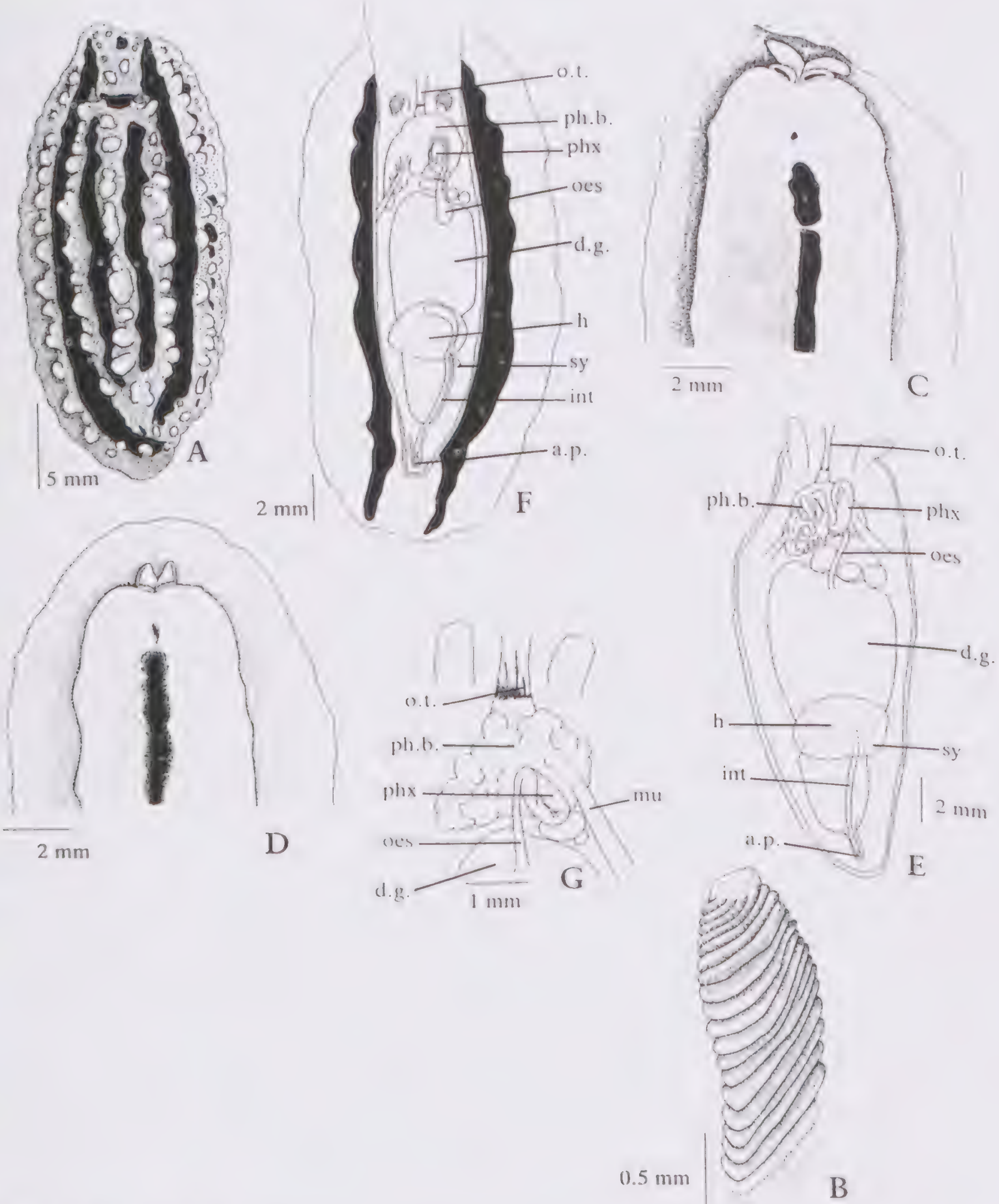


Fig. 9. *Phyllidia alyta* sp. nov.

A. Holotype: specimen F (Maldives): dorsal; B. specimen J (Maldives): rhinophore; C. Paratype: specimen G (Maldives): foot + oral tentacles; D. specimen B (Maldives): foot + oral tentacles; E. specimen C (Maldives): digestive morphology; F. specimen B: dorsal + digestive morphology; G. specimen M (Mauritius): magnification of o.t., ph.b., phx + oes

ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla visible. Two large muscles attach the pharyngeal bulb to the dark black body cavity lining. The pharynx is thick when it leaves the pharyngeal bulb and upturns to loop through the nerve ring, where it thins perceptibly. The oesophagus is rather long, and inserts in the top quarter of the digestive gland. The digestive gland is bipartite, constricted at the level of the pericardium in the lower one third. The pericardium is very small, and covers the syrinx. The intestine leaves the digestive gland at the level of the pericardium, curves over and around it, descending on the right side of the digestive gland. It is marked by two black lines which continue onto the anal papilla.

Remarks: An abundance of specimens from the Maldives highlight the differences between *P. alyta* and *P. arabica*, both of which were common. Externally, *P. alyta* is much neater in appearance, and shows less variation; although the Mauritius specimens approach *P. arabica*, the observations and description clearly apply to this species. *P. arabica* always has a strong odour when freshly collected, this species does not (as noted by Yonow and Hayward 1991). The mucus produced by this species reacts with 5% formaldehyde to produce hard amber globules on the dorsal surface of the animal and on the rhinophores.

Etymology: From the Greek *alytos*, meaning on unbroken or continuous line, referring both to the four dorsal black lines and the line on the sole of the foot.

Phyllidiella zeylanica (Kelaart 1858)
Figs. 10A–G

Synonymy:
Phyllidia zeylanica Kelaart 1858: 120 (Sri Lanka); Eliot 1906b: 674, pl. 42, fig. 10 (Kelaart's specimen); Narayanan 1968: 205, fig. 14, 16 (India); Burn 1970: 37, fig. 1, pl. 6a, b, c (India); Rao *et al.* 1974: 121, figs. 2c–e (Laccadives); Yonow & Hayward 1991: 23, fig. 13D (Mauritius).
P. varicosa: Risbec 1929: 49, figs. 6, 7b, 8a, b (Madagascar).
P. nobilis: Edmunds 1972 (part): 79, figs. 2A, C, E, F, H (Seychelles).

Material examined:
A. 38 × 14 mm; Nakatcha Tila, North Male Atoll, Maldives; 20 m depth; 12 May 1990 (green in life).
B. 25 × 10 mm; Nakatcha Tila, North Male Atoll, Maldives; 20 m depth; 12 May 1990 (green in life).
c. 12 × 6 mm; Maaya Tila, Ari Atoll, Maldives; 30 m depth; 14 May 1990 (smelly in life).
D. 14 × 6 mm; Maaya Tila, Ari Atoll, Maldives; 30 m depth; 14 May 1990.
e. 12 × 6 mm; Toroca, Ari Atoll, Maldives; 20 m depth; 19 May 1990.
F. 18 × 7 mm; Fulidoo house reef, Felidoo Atoll, Maldives; 20 m depth; 12 January 1991 (smelly, exuded white slime in life).
G. 17 × 11 mm preserved, curled; Maaya Tila, Ari Atoll, Maldives; 33 m depth, 18 January 1991.
h. 12 × 5 mm; Kkuramathi house reef, Rasdhu Atoll, Maldives; 16 m depth, 19 January 1991.
I. 15 × 8 mm preserved, contracted; Foteo West Reef, Felidhoo Atoll, Maldives; 20 m depth, 25 April 1991 (SH).
J. 16 × 10 mm preserved; Dok Mai, south of Phuket, Thailand; 26 November 1986 (KRJ).
K. 15 × 6 mm preserved, extended; WAM st. 1, 1–4 m depth, subtidal rocks, Flying Fish Cove, Christmas Island, Indian Ocean; 11 February 1987 (WAM no. 559–86).
L. 14 × 7 mm preserved, curled; WAM st. 3, 5–15 m depth, Ethel Beach, Christmas Island, Indian Ocean; 20 February 1987 (WAM no. 608–86).

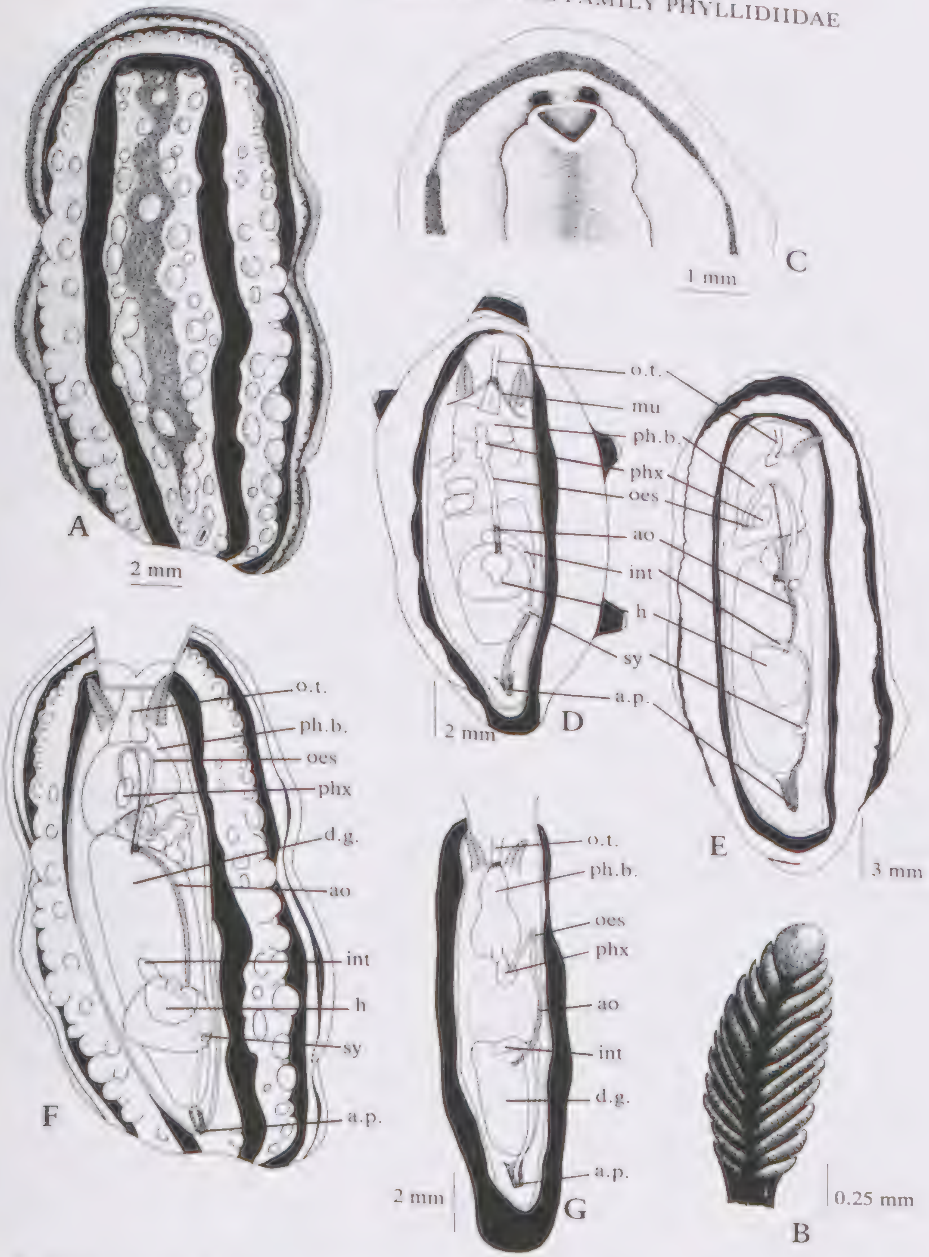


Fig. 10. *Phyllidiella zeylanica* Kelaart (Maldives)
A. specimen A: dorsal; B. specimen I: rhinophore; C. specimen F: foot + oral tentacles; D. specimen I: dorsal + digestive morphology; E. specimen B: dorsal + digestive morphology; F. specimen A: dorsal + digestive morphology; G. specimen F: digestive morphology
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, ao = aorta, d.g. = digestive gland, int = intestine, h = heart, sy = syrinx, a.p. = anal papilla

m. 17 × 9 mm preserved, slightly curled; Willy's Rock, Seychelles; 12 m depth under rock; 23 March 1992 (PK).
n. 20 × 7 mm preserved; BMNH (no label, relabelled BMNH/NY/1).
o. 15 × 8 mm preserved slightly curled; BMNH (no label, relabelled BMNH/NY/1).
p. 13 × 6 mm preserved; Flying Fish Cove, Christmas Island, Indian Ocean; 26.3.33 (BMNH Dr. Harms).

Description: Although there is some variation between individuals, the species is well distinguished (see references listed in the above synonymy) and therefore a general description will suffice. The largest specimen measured 38 mm when alive, the smallest 12 mm. Two specimens were noted to be green with black lines when alive, and the two had pungent smells. The mantle is elongate oval, pale pink with black lines and rhinophores, and flattened in profile. The most constant markings are the two central black rings. The innermost is *always* squared anteriorly, enclosing the rhinophores and anus, and thicker than the others. It also encloses two rows of tubercles which may or may not have a black line running between them.The second black ring is thinner and encloses a double row of tubercles on each side. It is either submarginal, or followed by a line of tiny pustules and another very thin black line, which is usually incomplete (fig. 10A). The rhinophores are long and sharply pointed; the lamellate portion is black and the stalk pale grey-white. There are twelve distinctive lamellae which join together along the midline (fig. 10B).

Ventrally, the sole is grey, darker centrally, and the hyponotum is so thin that the black and pale banding is clearly visible. Anteriorly the foot is deeply sculptured, forming a triangular depression in the region of the mouth. Above this, the head is clearly visible and the rounded oral tentacles arise from it. They are tipped with black in life as well as in the preserved specimens (fig. 10C).

Internally, the cavity lining and the peritoneum are jet black, but both are unpigmented around the pericardium. The oral tube is a solid opaque white structure. In the majority of the specimens there is a black band across it, or some black speckling. It is asymmetrical with a bend to the left, where it curves and enters the pharyngeal bulb. The bulb itself is small in comparison to *Phyllidiella rudmani* but is covered in leaf-life glands which fill the cavity normally assigned to the bulb in the genus *Phyllidia*. These glands are grey or ochre, and the pharyngeal bulb opaque creamy white. The blood gland is white or grey. The pharynx is swollen where it leaves the bulb slightly off centre to the left. It narrows abruptly and upturns to go through the nerve ring located at the anterior end of the pharyngeal bulb, and back down in a straight line, attached to the black aorta. There is a black pigment spot where the oesophagus and aorta meet, and there is a long stringy muscle extending from the top loop of the oesophagus to the digestive gland. The distal part of the intestine and anal tube are black. The pericardium is large, covering the large trilobed ventricle beneath it.

This is the first species in which the bulb has been in varying stages of protrusion/contraction; the bulb becomes a continuous extension with the oral tube (fig. 10G).

Remarks: All the preserved material is grey and black, without exception, in contrast with the reports by Burn (1970) and Rao *et al.* (1974) of preserved specimens becoming yellowish green. *P. zeylanica* characteristically curls the edges of the mantle under along the longitudinal axis when alive, and this is very marked upon preservation (see figs. 10A, D, E, F). The species appears to be limited in distribution to the western Indian Ocean.

Phyllidiella rudmani Brunckhorst 1993
Figs. 11A–G

Synonymy:
Phyllidiella rudmani Brunckhorst 1993: 62, fig. 29d, pl. 7c, d.

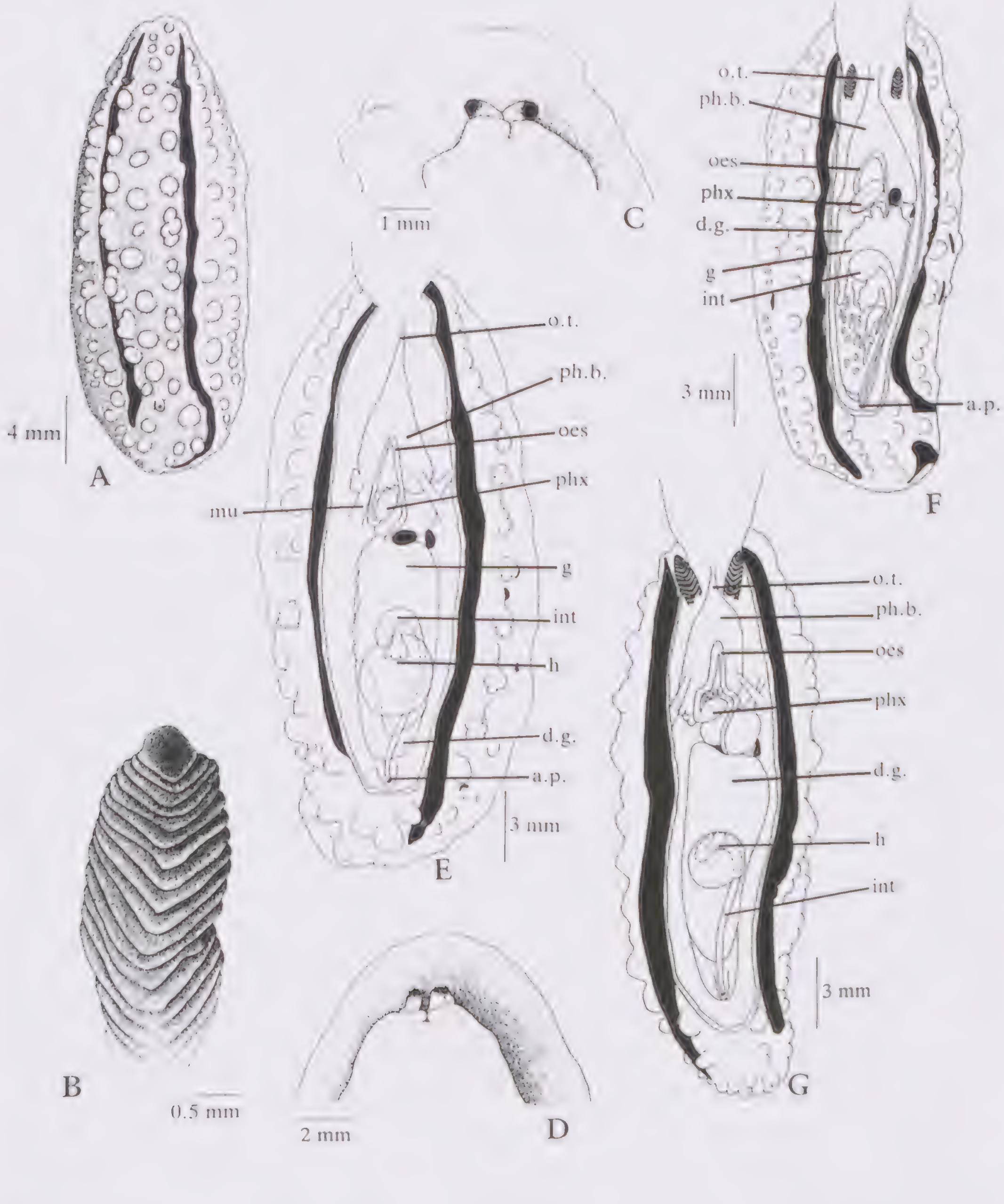


Fig. 11. *Phyllidiella rudmani* Brunkhorst (Maldives)
A. specimen B: dorsal; B. specimen G: rhinophore; C. specimen G: foot + oral tentacle; D. specimen F: foot + oral tentacle; E. specimen F: dorsal + digestive morphology; F. specimen G: dorsal + digestive morphology; G. specimen C: dorsal + digestive morphology
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, d.g. = digestive gland, int = intestine, h = heart, a.p. = anal papilla, g = gonad

Material examined:
A. 40 × 13 mm; Nakatcha Tila, North Male Atoll, Maldives; 20 m depth; 12 May 1990.
b. 30 × 10 mm; Nakatcha Kura Tila, North Male Atoll, Maldives; 12 m depth; 12 May 1990.
C. 31 × 11 mm; Nakatcha Kura Tila, North Male Atoll, Maldives; 12 m depth; 12 May 1990.
D. 35 × 10 mm; Kandholudu Tila, Ari Atoll, Maldives; 10 m depth; 15 May 1990.
E. 35 × 13 mm; Maaya Tila, Ari Atoll, Maldives; 33 m depth; 18 January 1991.
F. 32 × 14 mm; Maaya Tila, Ari Atoll, Maldives; 33 m depth; 18 January 1991.
G. 27 × 11 mm preserved; Ellaidhoo, Ari Atoll, Maldives; 19 m depth in cave; 5 November 1991 (HD).

Description: This species is pinkish white with two black lines and black rhinophores (fig. 11A). The mantle bears compound tubercles arranged in longitudinal rows. The tubercles are composed of a larger central one with up to eight smaller ones arranged around it, sometimes forming a star shape, usually regular in shape but sometimes sloppy. In many of the largest tubercle groups, the central one shows signs of subdivision. There are three central rows, with the middle row extending to the mantle margin anteriorly. The pair of black lines extend from in front of the rhinophores to beyond the level of the anus, very rarely to the mantle edge in either direction. The lateral rows of tubercles originate behind the rhinophores and extend to the posterior margin. There are then two to four lines of tubercles, the last one or two reduced to rows of tiny pustules. Rarely, there is the solitary black patch or speck in this region.

The rhinophores are long and tapering, issuing from slightly raised pinkish white sheaths. Their stalks are pinkish white, and the lamellate portions are black (fig. 11B). Ventrally, the foot is notched anteriorly in all but one preserved specimen, and the oral tentacles in life were long. In the preserved material, they are conical, attached to the mouth, and tipped with black in three specimens (figs. 11C, D). The gills are black, with a black line in the crevice between the hyponotum and the foot.

Internally, the cavity lining is grey in all but one specimen (f) where it was black; the gut lining is dusty black, which intensifies around the pericardium. The unmarked oral tube leads into an elongated pharyngeal bulb. This structure is smooth and bears a few smooth lobes on its flattened posterior side. The pharynx is thick and bulbous where it exits the pharyngeal bulb posteriorly. The tubular oesophagus originates on the lower left side, immediately turning upwards half-way along the pharyngeal bulb where it does a U-turn through the nerve ring and continues back down over the reproductive organs and inserts on the anterior face at the top of the digestive gland. The digestive gland occupies over half the body cavity: it is broad anteriorly and tapers posteriorly. Approximately half-way the intestine emerges, overlain by the pericardium. The intestine can be followed up and over, down the right side of the digestive gland to the anal tube. The pericardium is circular, and the ventricle clearly visible at the top overlying the intestine (figs. 11E, F, G).

The reproductive organs in this species are visible dorsally as a large ovoid structure, with the tube leading externally. On this are located two hard black tear-drop-shaped spheres, one medially where the oesophagus joins the digestive gland, and the second far right on the side of the reproductive organs. In the Ellaidhoo specimen (g), the gonad was bright pinkish red, interspersed with the digestive gland, and the other specimens varied from cream to apricot.

Remarks: The genus *Phyllidiella* typically has a mass of many oral glands external to the pharyngeal bulb. Although the arrangement in this species is unlike that in typical specimens belonging to the genus *Phyllidiella* (see for example *Phyllidiella zeylanica*), *P. rudmani* is presently maintained in this genus until further species with a similar arrangement are

TABLE 2

Differences between *Phyllidia arabica* and *Phyllidia alyta* sp. *nov.*

CHARACTERS	*P. arabica*	*P. alyta*
longitudinal black lines	4 touching	4 individual
marginal black marks	transverse	absent or rare
anterior edge of foot	notched	concave
oral tentacles	orange-tipped	grey
black on sole	dotted line	unbroken line with 1 or 2 dashes anteriorly
odour	very strong	none
oral tube	no markings	black lines or spots
pharyngeal bulb	symmetrical	asymmetrical
pharynx	tubular	swollen
muscles	fibrous flat sheets	smaller bundles
size	8–105 mm	13–40 mm
rhinophore lamellae	22–26	18–20

described. The majority of the specimens, preserved in 5% formaldehyde in glass vials, etched the inside of the glass. No particular odour was observed when the live animals were handled. These specimens are assigned to *P. rudmani* although there are some differences from the original description: here, the oral tentacles are tipped with black and there is a black line between the foot and the hyponotum. Internally, there are small oral glands located on the posterior face of the pharyngeal bulb, and the reproductive system appears to be different.

Fryeria rueppelii Bergh 1869
Figs. 12A–H; table 3

Synonymy:
Phyllidia pustulosa: Rüppell & Leuckart 1828: 36, pl. 11 figs. 1a,b (Red Sea).
Fryeria pustulosa: Gray 1857: pl. 312, fig. 5a, b (direct copy of Rüppell & Leuckart 1828 figs); Vayssière 1912: 87 (Red Sea).
Fryeria rueppelii Bergh 1869, 514, nom nov. for Rüppell & Leuckart's specimen; Brunckhorst 1993: 43, figs. 7–9A (Red Sea).
Fryeria rueppellii: Bergh 1875: 663, taf. XVI, figs 5–10 (Red Sea).
Phyllidiella pustulosa: Eales 1938: 110, pl. XI, fig. 1 (Red Sea).
Phyllidia varicosa: White 1951: 252 (Red Sea).
Reyfria rueppelii: Yonow 1986: 1418, figs. 9, 12 f–j; Yonow 1988: 149, pl. 8 (Red Sea).

Material:
A. 35 × 21 mm preserved; Aden Arosal al Baht, Gulf of Aden; March 1988 (University of Rostock, RC-N31).
B. 28 × 16 mm preserved; as above.
C. 25 × 19 mm preserved; south reef plateau, Sanganeb, Red Sea; 1 m depth; 27 March 1991 (TP).
D. 31 × 15 mm preserved; Dahab, Sinai peninsula; November 1990.
e. 40 × 17 mm preserved; Gulf of Suez; 1912, ex-Bannwarth collection, Senckenberg Museum 920a/1.
f. 29 × 18 mm preserved; Red Sea, E. Rüppell leg., Senckenberg Museum 219/175.

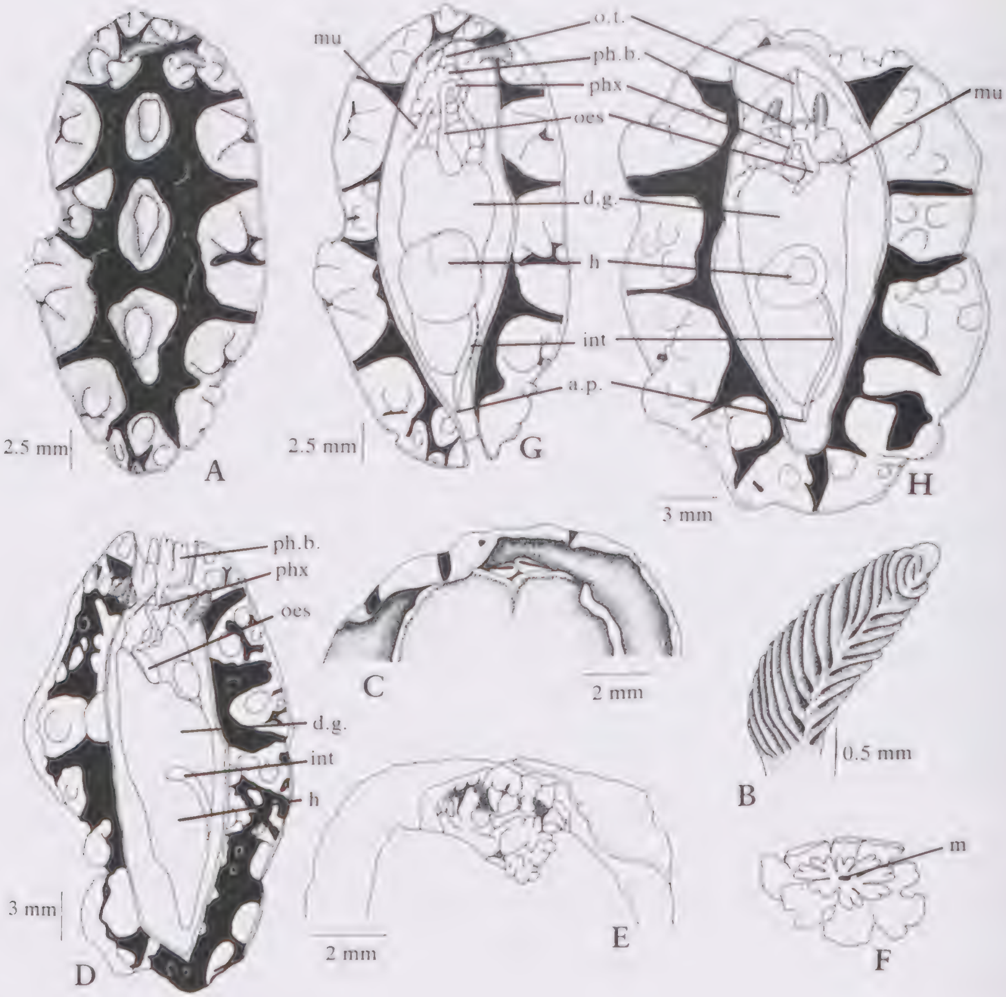


Fig. 12. *Fryeria rueppelli* Bergh (Red Sea)
A. specimen D: dorsal; B. specimen D: rhinophore; C. specimen D: foot + oral tentacles; D. specimen A: dorsal + digestive morphology; E. specimen A: ventral anterior foot with ph.b extruded; F. specimen A: magnification of ph.b. with lappets uncurled; mouth at centre; G. specimen D: dorsal + digestive morphology; H. specimen C: dorsal + digestive morphology
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, d.g. = digestive gland, int = intestine, h = heart, a.p. = anal papilla, m = mouth

g. 21 × 17 mm preserved, bent; Red Sea, E. Rüppell leg., Senckenberg Museum 219/175.
h. 38 × 22 mm preserved, curled; Red Sea, Bannwarth collection (BMNH 218), the specimen described by White (1951).

Description: The four recently collected specimens a–d are virtually identical to those previously described from the Red Sea (Yonow 1986, 1988). Briefly, the five median tubercles, with the first in front of the rhinophores, are the largest, white with orange tips. There is a second row of tubercles on either side which originates with a tubercle just behind each rhinophore, each white with orange tips. The third row of tubercles forms a ring around the others, as does the fourth row. Beyond this, the tubercles are scattered, much smaller, and rarely orange. The margin is completely edged with orange. The dorsum is black centrally, and between the second and third rows extends to the edge as transverse rays (fig. 12A). The 'older' preserved specimens e–g have lost the black pigment but the arrangement of tubercles matches the above, and the posterio-ventral anus is clearly visible. The rhinophores, orange in life, are curved and finger-like, the lamellae thick and not meeting medially. The number of lamellae ranges from 11 to 18 (fig. 12B).

Ventrally, the foot is concave in five specimens and divided in two. The oral tentacles are long and thin, and the head is visible on all animals. In one specimen (b), the grooves along the outer sides of the oral tentacles are visible (fig. 12C). The pharyngeal bulb was preserved in the extended state in specimen a (figs. 12D, E). It consists of two sets of lobes: the larger, outer ones tend to be trapezoidal in shape with a dent or notch on the outer edge (fig. 12F). There are eight of these, joined for approximately one third of their length. The second set consists of eight deeply divided regular lobes, long and thin, joined just at the base around the mouth opening. The inner lobes are attached to the outer "lappets" by a membrane extending between the two for most of the length of the inner lobes (fig. 12F).

Internally, the anatomy varies only slightly in the four specimens dissected, but consistent features are as follows: the large digestive gland (75–80% of the body cavity); the large pericardium located centrally, with the trilobed ventricle; a flattened and foreshortened pharyngeal bulb with lobes on the posterior face; two strong attachment muscles; and an oral tube with no black markings. In two specimens (b and c) the pharyngeal bulb is pinkish. Two specimens (c and d) were similar in the following respects: the pharynx exits the bulb centrally on the posterior face, loops dorsally through the nerve ring, and straight down to the anterior concavity of the digestive gland (figs. 12G, H). The Gulf of Aden specimens (a and b) are very flat, resulting from peculiar preservation: in one specimen (b) there is a very long (flattened) portion of the pharynx anterior to the nerve ring which cannot be traced to its origin on the pharyngeal bulb – it appears to insert just to the left of the oral tube, but this is probably a distortion. In the specimen with its mouthparts extruded (specimen a; figs. 12D–F), the anatomy is as for the other specimens. The pharyngeal bulb is pushed right through the oral tube, with just the retractor muscles visible. The pharynx can be traced from within the oral tube, bending twice, through the nerve ring, then down with one bend into the concavity of the digestive gland. The gonads are relatively voluminous in this specimen. The intestine is visible for all of its length.

Remarks: the systematics of this species has been discussed previously (Edmunds 1972; Yonow 1986). Since these publications, two species of *Fryeria* have been described, *F. marindica* (Yonow & Hayward) and *F. menindie* Brunckhorst. *F. menindie* is found to be junior synonym of *Phyllidia picta* Pruvot-Fol, which is assigned here to *Fryeria* (*q.v.*). Both species are described and illustrated in detail, both externally and internally, in this review and the differences are given in Table 3.

Fryeria marindica (Yonow and Hayward 1991)

Figs. 13A–F; table 3

Synonymy:
Fryeria rueppellii: Bergh 1889: 862, taf. 84, figs. 19–22 (Mauritius); Edmunds 1972: 84, fig. 4a (Seychelles).
Reyfria marindica Yonow & Hayward 1991: 23, figs 10C, D, 13E (Mauritius).

Material:
A. 17 × 8 mm; Nakatcha Tila, North Male Atoll, Maldives; 20 m depth; 12 May 1990.

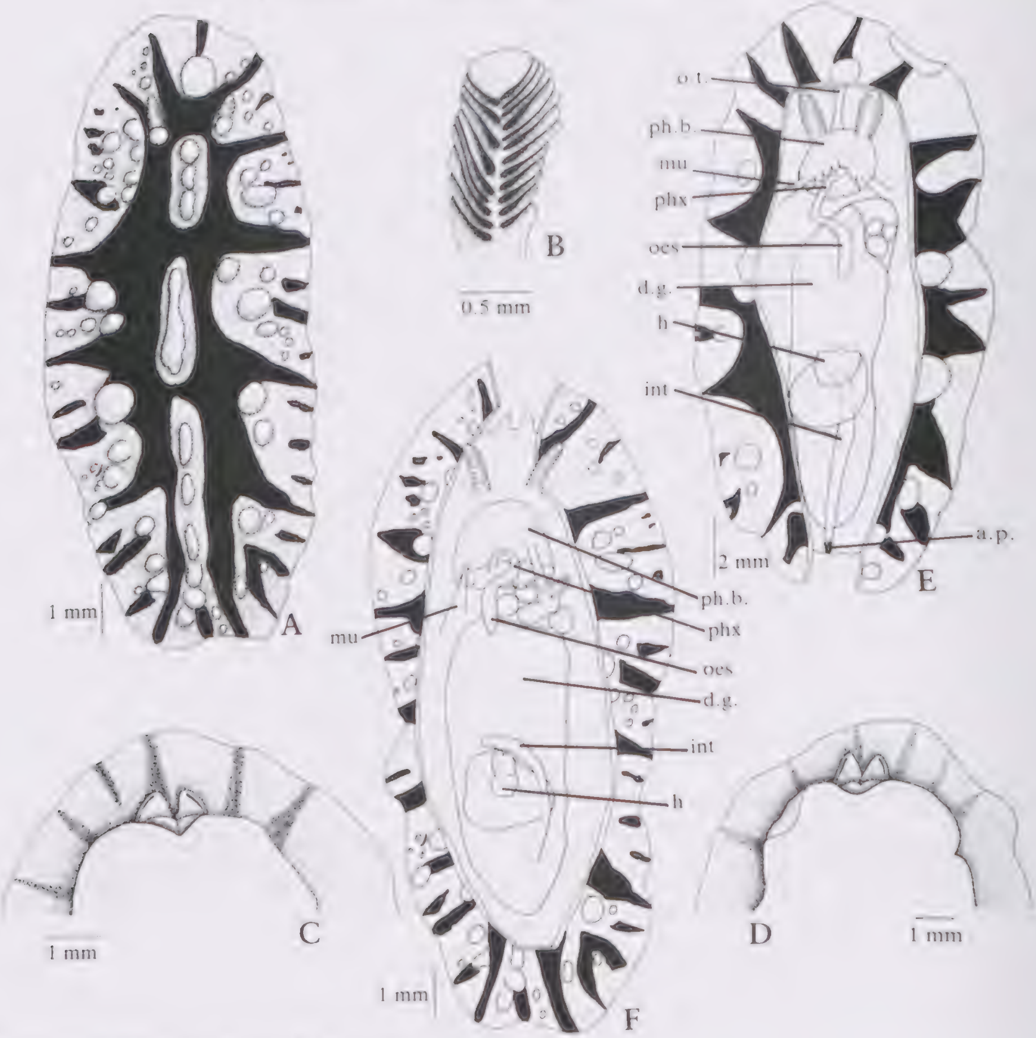


Fig. 13. *Fryeria marindica* (Yonow & Hayward) (Maldives)
A. specimen A: dorsal; B. specimen B: rhinophore; C. specimen A: foot + oral tentacles; D. specimen B: foot + oral tentacles; E. specimen B: dorsal + digestive morphology; F. specimen A: dorsal + digestive morphology
ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, d.g. = digestive gland, int = intestine, h = heart, a.p. = anal papilla

B. 20 × 11 mm; Maaya Tila, Ari Atoll, Maldives; 29 m depth; 14 May 1990 (figured in Yonow & Hayward 1991: fig. 13E).
c. 20 × 10 mm; Horseshoe Rock, Seychelles; 6 m depth on coral head; 24 March 1992 (PK).
d. 17 mm in length; Fehigili, Lhaviyani Atoll, Maldives; 27 m depth; 5 March 1991 (SH, photographed but not collected).
e. 18 × 6 mm preserved, slightly curled (BMNH no label, relabelled BMNH/NY/1).

Description: All five animals are alike in having a median row of eight or nine orange-tipped tubercles and a black line on each side which extends laterally in six rays to the edge (fig. 13A); in one specimen (b), the black stops just short of the margin. The first lateral row of tubercles each side of the median, and outside the black longitudinal line, are also tipped with orange. The rest of the tubercles are scattered in the semi-circular areas created by the black; some of the larger ones may be orange. The orange rhinophores bear 10–12 lamellae which almost meet medially in an alternating series (fig. 13B). Ventrally, the specimens are identical: the edge of the foot is deeply concave, almost notched, the bilobed head is visible, and the oral tentacles are conical, grey in life, with a groove visible along the outer edge. The anterior edge of the foot is visibly thickened (figs. 13C, D).

Internally, both Maldive specimens were identical, with a thin-walled oral tube and a large hemispherical pharyngeal bulb with retracted lobes around the posterior edge (figs. 13E, F). The pharynx is inserted on the flattened, almost concave, face of the bulb, goes through the nerve ring, bends and inserts on the top of the digestive gland. The retractor muscles are attached dorsally and the grey blood gland is prominent. The reproductive organs are clear and discrete, slotting inbetween the pharyngeal bulb and the digestive gland. The pericardium is not particularly large (cf. *F. rueppelii*) and overlies the intestine. In both specimens, the intestine is relatively thick and outlined in black, and can be traced to the anal opening in the better preserved specimen (b) (fig. 13E), which is tipped in black.

Remarks: These specimens are consistent in external morphology with the other Indian Ocean material described and illustrated by Bergh (1889: Mauritius), Edmunds (1972: Seychelles), and Yonow and Hayward (1991: Mauritius). *F. marindica* is presently known only from the Indian Ocean. It is distinguished from its congenerics by its external colour and tubercular pattern: two median black lines and six perpendicular rays to the edge. All species of *Fryeria* appear to be very similar internally: differences are outlined in Table 3.

Fryeria picta (Pruvot-Fol 1957)

Figs. 14A–K; table 3

Synonymy:

Phyllidia picta Pruvot-Fol 1957: 110, figs. 5–12 (no locality).

Fryeria rueppelli: Baba & Hamatani 1975: 178, fig. 5 (Japan); Pruvot-Fol 1957: 114, pl. 1, figs. 3, 4 (Viet Nam); Eliot 1906A: 563 (Maldives).

Fryeria menindie Brunckhorst 1993: 47, fig. 26B, pl. 4H, 5A (North Queensland, Papua-New Guinea).

Phyllidia variabilis: Risbec 1956: 24, part (Viet Nam).

Baba 1984–1987 pers. comm.: numerous photos, drawings, and unpublished manuscripts of external and internal morphology (Japan).

Material:

A. 24 × 13 mm preserved; Tulamben, Bali, Indonesia; 3–20 m depth; November 1990 (HD).

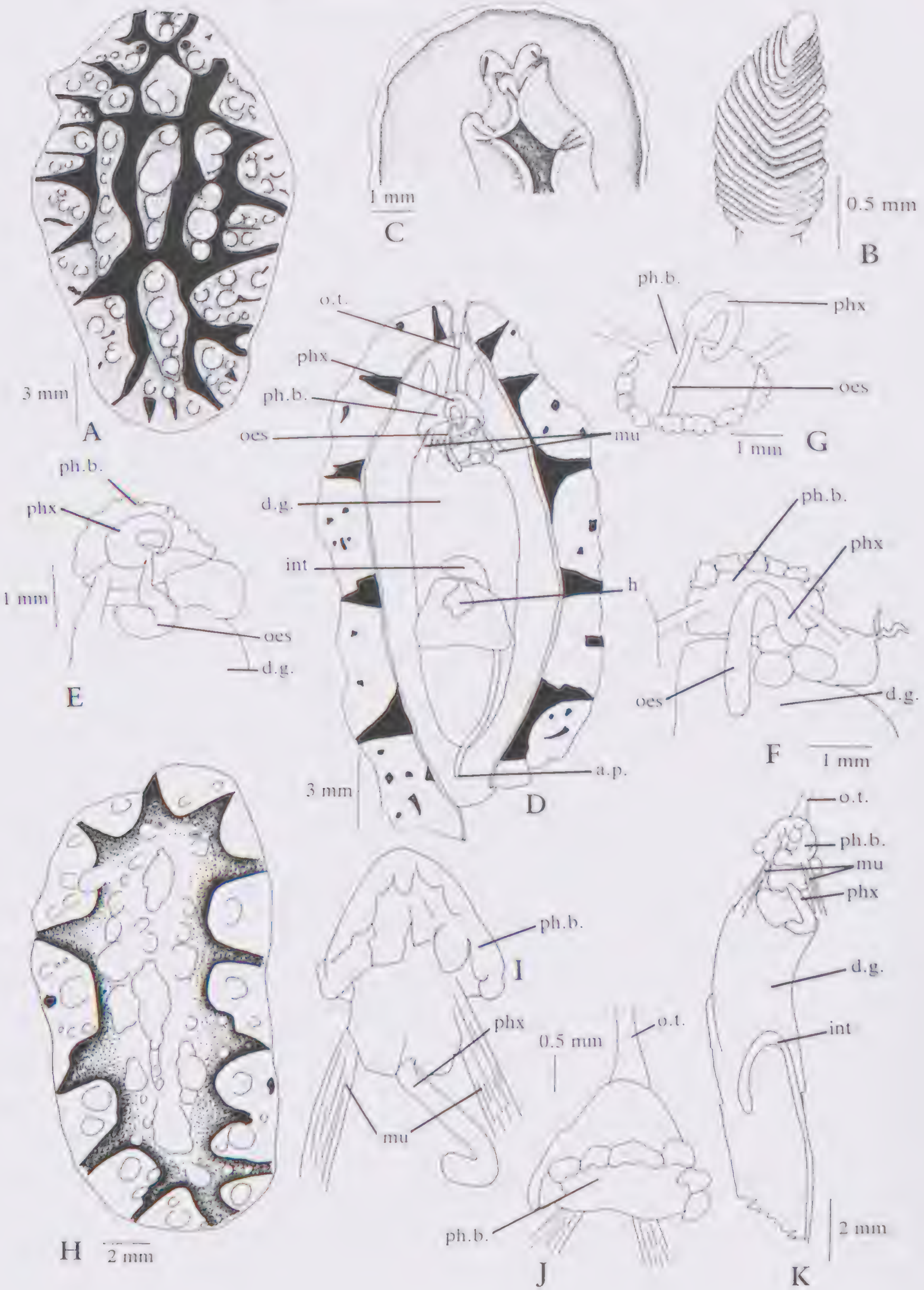
B. 15 × 11 mm preserved; subtidal rocks, st. 1, Flying Fish Cove, Christmas Island, Indian Ocean; 1–4 m depth; 11 February 1987 (WAM 558–86).

C. 14 × 7 mm preserved; as b above.

D. HOLOTYPE: 21 × 10 mm preserved, *P. picta* Pruvot-Fol; BMNH 1854.7.19.91.

e. *P. variabilis*: Risbec (1956, part); MNHN 1481.E.33489 (Viet Nam).

Description: The ground colour is black, formed by a central region which has six or seven rays extending to the margin; the non-black areas have a bluish tinge (fig. 14A). There is a median row of tubercles which coalesce to form a discontinuous longitudinal ridge; the tubercles, upwards of ten, are tipped with yellow-orange. The lateral lines are similar, but with fewer tubercles merging to form four or five areas, or occurring singly. The largest tubercles in the semi-lunar areas are yellow-tipped, and there are many smaller pustules and scattered black lines and patches. The rhinophores bear 13 to 18 leaves, which are more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compressed than in *F. rueppelii*, and join long the midlines (fig. 14B). Ventrally, the foot, mouth, and oral tentacles are as in *F. marindica* (fig. 14C).

Three recently collected specimens were dissected and were very similar (fig. 14D). The oral tube opens into the pharyngeal bulb, which is hemi-spherical. They appear to be in different stages of eversion: in the small Christmas Island specimen (c), the bulb is lumpy anteriorly, and slightly more divided around the posterior edge, but the eight lobes are indistinguishable (fig. 14E). In the larger specimen (b), the lobes are definitely visible anteriorly and the posterior is not flat with a distinct edge (fig. 14F) as in the other two species of *Fryeria* discussed above. In the Bali specimen (a) the eight lobes are clearly visible when the bulb is turned up slightly (fig. 14G); they are contracted around the sides and ventral surface of the bulb's posterior edge (fig. 14D). The retractor muscles are strong and attached on the posterior face. In all specimens, the pharynx inserts on this face, towards the dorsal edge. It is directed anteriorly and loops through the nerve ring: at this point there is a definite narrowing. Then there is a short, almost straight oesophagus which inserts into the digestive gland anteriormost in two specimens and part-way down in the third (specimen b; fig. 14F). In specimen c (fig. 14E) there is a sharp bend before the oesophagus joins the digestive gland. The intestine, as in the other species of *Fryeria*, is visible along its length.

Remarks: Examination of the holotype of *P. picta* Pruvot-Fol shows it to belong to the genus *Fryeria*. The dorsal pattern of tubercles as well as indications of black pigment (see fig. 14H) are those of *F. menindie* as described by Brunckhorst (1993); the confusion with his dark form of *P. coelestis* is understandable, but examination of the internal anatomy should have clarified its position. The camera lucida drawings presented here (figs. 14I–K) coincide precisely with those of Pruvot-Fol and are undoubtedly of the same specimen. This specimen was in pieces, but a thorough examination of the skin revealed no anal hole when viewed from both the external or internal side. Pruvot-Fol assigned her specimen to *Phyllidia* on a "rudimentary examination of the viscera" but the species, a valid one, must be reassigned to *Fryeria picta*, and *F. menindie* becomes a synonym. The species is presently restricted to the eastern Indian Ocean and Pacific Ocean, and with its congenerics is presented in Table 3 below.

TABLE 3

Comparison between the species of *Fryeria: F. rueppelii, F. marindica*, and *F. picta*

CHARACTERS	*F. rueppelii*	*F. marindica*	*F. picta*
tubercles	white + orange, connected	white + orange, connected	blue/yellow orange, isolated
ground colour	black	white/blue	black
edge colour	orange	–	–
dorsal ridges	1 white/orange + 2 black	1 white/orange	3 white/orange

←

Fig. 14. *Fryeria picta* (Pruvot-Fol)

A. specimen C (Christmas Island): dorsal; B. specimen A (Bali): rhinophore; C. specimen A: foot + oral tentacles; D. specimen A: dorsal + digestive morphology; E. specimen C: magnification of ph.b., phx + oes; F. specimen B (Christmas Island): magnification of ph.b., phx + oes; G. specimen A: magnification of ph.b., phx + oes; H. Holotype: specimen D (no locality): dorsal; I. Holotype: dorsal view of ph.b., phx + oes; J. Holotype: ventral view of ph.b. showing glands along the ventral edge; K. Holotype: digestive morphology

ABBREVIATIONS for dissections of digestive anatomy: o.t. = oral tube, ph.b. = pharyngeal bulb, mu = muscle, phx = pharynx, oes = oesophagus, d.g. = digestive gland, int = intestine, h = heart, a.p. = anal papilla

CONCLUSION

This ongoing study into the anatomy and morphology of the Phyllidiidae is proving very interesting. The specimens, mostly from the Indian Ocean, made available to me were preliminary sorted into similar 'species' groups, and once drawings and dissections were begun, they were more easily assigned to four genera, *Phyllidia*, *Phyllidiella*, *Phyllidiopsis*, and *Fryeria*. *Phyllidia* and *Fryeria* are most similar externally, being black, white, and orange with orange rhinophores and a tuberculate dorsum. In some cases only very careful scrutiny for the anal opening enabled distinction between *F. picta* and the dark form of *P. coelestis*. However, with a practised eye it did become easier. *Phyllidia* are either of the '*arabica*' pattern, linear patterns of black, white, and orange, or of the '*ocellata*' colour group, with an orange ground colour. Five species of *Fryeria* are described from the Indo-Pacific, but only three species are commonly found and they show no geographical overlap. Internally, they differ very little but are easily distinguished by external characters (*q.v.*, Brunckhorst 1993). Of the remaining two species, one is found in Micronesia and the second is known only from Guam; a sixth species of *Fryeria* is known from the Mediterranean. *Phyllidiella* and *Phyllidiopsis* resemble one another externally in the lack of orange tubercles. However, the first is more tuberculate while the second is more ridged. *Phyllidiella* are generally grey or pinkish with black, and *Phyllidiopsis* usually have additional ochre or brownish lines. The two species of *Phyllidiella* discussed here have black rhinophores, while a preliminary survey of *Phyllidiopsis* reveals half black-half white or ochre rhinophores. A very large number of *Phyllidiella* collected in the Maldives appear to belong to five species, but their anatomy has yet to be investigated. The differences in pharyngeal anatomy between *P. zeylanica* and *P. rudmani* is interesting, and it is hoped that the remaining specimens will shed light on this feature.

ACKNOWLEDGEMENTS

I am grateful to all the collectors and museums for entrusting me with their specimens and photographs over the years. Dr. P. J. Hayward (University of Wales, Swansea) has been a constant source of knowledge on the intricacies of taxonomy, and I thank him for many useful discussions. I am grateful to Dr. R. Janssen (Senckenberg) for permission to dissect the holotype of *Phyllidia multituberculata*.

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J. Conch., Lond. **35**: 517–519 (1996)

OBITUARY: RODGER WATERSTON, 1912—1996

Andrew Rodger Waterston was born at Ollaberry, Shetland, 11 March 1912, the younger son of the entomologist James Waterston who was, at that time, a minister of the United Free Church. With his death in Edinburgh on 12 July 1996 the zoological fraternity lost a great scholar naturalist whose all-round knowledge of the Scottish fauna was second to none. Although perhaps best known as an entomologist, with a particular interest in the insects of the Middle East, his contributions to malacology were considerable. He read zoology at Edinburgh University, submitting his B Sc honours thesis "On some points in the anatomy, histology and relationships of a new British slug (genus *Limax*)", a study of the greenhouse alien *L. nyctelius*. He took part in the University's 1935 expedition to investigate the natural history of Barra, the Hebridean island which was to become Rodger's summer home for much of the last 30 years and, in 1938, married a fellow member of that expedition, the mycologist Marie Campbell.

Rodger Waterston was introduced to the Conchological Society by Charles Oldham and A E Boycott, with whom he collected non-marine molluscs in Ireland. In 1931 he had the foresight (or Scottish canniness) to subscribe six guineas for Life Membership; he was also a Life Member of the Malacological Society of London from 1935. He was appointed Assistant Keeper in the Department of Natural History of the then Royal Scottish Museum in September of that year, with responsibility for the invertebrate collections. Rodger was an active fieldworker, very interested in species distribution and with a good eye for *Vertigo* and other minute species. After Boycott's death in 1938, he took over the Society's Recorder for non-marine Mollusca, with a view to bringing out a new edition of Roebuck's distribution Census, but this intention was frustrated by the Second World War. In July 1943 the Society's Proceedings record that "the Recorder of non-marine Mollusca is now serving with the Forces and has been unable to provide his usual report". The Census record books were left with the Hon. Secretary, J W Jackson. Although unavoidably inactive because of his service abroad, Waterson held the post of non-marine Recorder until 1947, when he was succeeded by A E Ellis.

Rodger's wartime record was distinguished. After service with the Royal Scots he was seconded in 1943 to the Middle East Anti-Locust Unit as Chief Locust Officer. Although based in Cairo, his official duties were wide ranging, taking him from Egypt to Saudi Arabia, Ethiopia, Yemen and Palestine. He was the last of the senior staff to return to their museum duties after the war, not coming back to Edinburgh until 1952 after an absence of 13 years, for the last six of which he was the entomological adviser to the British Middle East Office and Attaché for Scientific Affairs at the British Embassies in Cairo and Beirut. In 1952 he received an OBE for his work with the Anti-Locust Unit. His interest in terrestrial molluscs remained active as in 1953 he donated to the museum his collection of more than 2000 specimens of Middle Eastern snails.

At the Royal Scottish Museum, Waterston became Keeper of Natural History in 1958, a post he held until his retirement in 1973. He did not subsequently relinquish zoological study but returned to his research on Middle Eastern dragonflies. In recognition of his distinguished service to the museum and to zoology he was accorded the special title Keeper Emeritus. His own collection of more than 2000 lots of non-marine molluscs, mostly for Scottish localities and all with meticulous locality data, was given to the museum in 1959. Many other important donations and bequests were acquired by the museum during his Keepership, including the collection of D K Kevan with whom Rodger had conducted much of his Scottish fieldwork. Outstanding among the bequests of Mollusca collections which he secured for the museum was that of A E Salisbury in 1961, at that time the largest shell collection in private hands in this country. In size alone it was twice that of the museum's entire previous shell collections. It is a tribute to Rodger Waterston's administrative abilities that he was able to overcome considerable difficulties in persuading the authorities not only to purchase Salisbury's extensive malacological library, without which the scientific value of the collection would have been much impaired (in fact, as the museum had no provision for the purchase of a private library, Rodger persuaded Salisbury to make the books the bequest and sell the museum the collection for the same amount!), but also to construct a Mollusca Study Room to house it and appoint, in 1966, the museum's first Curator of Mollusca to look after it.

The Mollusca collections were also enriched by Waterston's visits to the Hebrides, and particularly by his study of the fauna of the Loch Druidibeg Nature Reserve in South Uist. In 1982, in recognition of his contribution to the natural history of the Hebrides and to Scottish entomology, he was awarded the Neill Prize Medal by the Royal Society of Edinburgh, of which he had been a Fellow since 1946. Rodger Waterston had an active interest in zoological bibliography and was an active supporter of the Scottish Branch of the Society of the History of Natural History. He was one of the founders of the Scottish Natural History Library which, largely due to his efforts, received both the library of the Royal Physical Society of Edinburgh and the natural history holdings of the Royal Society of Edinburgh when its library was disbanded some ten years ago.

Though deeply missed, Rodger will long be remembered for his excellent collections and scientific publications but, much more than that, those of us who were privileged to serve under him will never forget his kindly encouragement, his seemingly limitless zoological knowledge so freely given to others, his fascinating reminiscences of malacologists and entomologists who to a younger generation were only names and, by no means least, his dry sense of humour. We mourn a gifted naturalist who was loved and respected by all who knew him. He is survived by his wife Marie and daughter Susan.

DAVID HEPPELL

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Alison Trew

J. Conch., Lond. **35:** 521–522 (1996)

COMMUNICATIONS

Applications published in the Bulletin of Zoological Nomenclature

The following Applications were published on 30 September 1996 in Vol. 53, Part 3 of the *Bulletin of Zoological Nomenclature*. Comment or advice on any of these applications is invited for publication in the *Bulletin* and should be sent to the Executive Secretary (I.C.Z.N.), c/o The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.

Case 2935

***Lirobarleeia* Ponder, 1983 (Mollusca, Gastropoda): proposed designation of *Alvania nigrescens* Bartsch & Rehder, 1939 as the type species**

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Abstract. The purpose of this application is to designate *Alvania nigrescens* Bartsch & Rehder, 1939 as the type species of the gastropod genus *Lirobarleeia* Ponder, 1983 (family BARLEEIDAE Gray, 1857). *A. nigrescens* is common in shallow water surrounding the Gallapagos Islands and is the species on which the genus was based. Ponder's (1983) designated type species was erroneously identified as *Alvania galapagensis* Bartsch, 1911, a similar deep water species known only from the type material.

Keywords. Taxonomy; nomenclature; Gastropoda; *Lirobarleeia*; *Lirobarleeia nigescens*; *Lirobarleeia galapagensis*; Galapagos Islands.

Case 2977

***Arca pectunculoides* Scacchi, 1834 and *A. philippiana* Nyst, 1848 (currently *Bathyarca pectunculoides* and *B. philippiana*; Mollusca, Bivalvia): proposed conservation of the specific names**

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Abstract. The purpose of this application is to conserve the specific names of *Arca pectunculoides* Scacchi, 1834 and *A. philippiana* Nyst, 1848 for two European bivalves. Since 1978 the name *Arca grenophia* Risso, 1826 has been generally, but incorrectly, adopted as a senior synonym of *A. pectunculoides*, the type species of *Bathyarca* Kobelt, 1891; however, *A. grenophia* is conspecific with *A. philippiana*. Use of *A. grenophia* in place of *A. philippiana* would create considerable confusion and its suppression is proposed. Both *A. pectunculoides* and *A. philippiana* are widely distributed from Norway to southern Morocco, the Canary Islands, the Azores and seamounts of the North Atlantic, and the Mediterranean. Both were originally described from Pleistocene fossils.

Keywords. Nomenclature; taxonomy; Mollusca; Bivalvia; *Bathyarca*; *Bathyarca pectunculoides*; *B. philippiana*; *B. grenophia*.

Opinions published in the Bulletin of Zoological Nomenclature

The following Opinions concerning Mollusca were published on 30 September 1996 in Vol. 53, Part 3 of the *Bulletin of Zoological Nomenclature*. Copies of these Opinions can be obtained free of charge from the Executive Secretary, I.C.Z.N., c/o The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.

OPINION 1844. *Aplysia juliana* Quoy & Gaimard, 1832 (Mollusca, Gastropoda): specific name conserved.
OPINION 1845. *Tropidoptera* Ancey, 1889 (Mollusca, Gastropoda): *Endodonta wesleyi* Sykes, 1896 designated as the type species.

ZINGIS RADIOLATA VON MARTENS (PULMONATA, UROCYCLIDAE) REDISCOVERED AT LAST

I have emphasized several times the crucial importance of an examination of the anatomy of *Zingis radiolata* and suitable material is still much required. The species has, however, been refound fortuitously. My colleague Sally Bidgood brought to me two small juvenile snails found on a pressed plant. These turned out to be *Zingis radiolata*, only the third time it has been collected to my knowledge and the first record for Tanzania. The details are as follows.

TANZANIA. Same District, Mkomazi Game Reserve, Kisima Hill, 4° 06′ S, 38° 05′ E, rocky hilltop with open scrub of *Apodytes*, *Combretum molle Encephalartos hildebrandtii*, *Euphorbia* spp., *Xerophytum* sp., etc., 1400 m., on *Vernonia holstii*, *Abdallah and Vollesen* no. 95/70, 30 April 1995.

This part of Tanzania is mostly dry but this particular area is less so and the morning dews would be adequate for the survival of Urocyclidae. The area is in a zone where 20–30″ of rain usually fall in four years out of five. With this more detailed locality data perhaps someone can now seriously search for adult material and preserve it properly for anatomical investigation.

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THEODOXUS FLUVIATILIS (L.) IN THE RIVER NORE, IRELAND

With the discovery, in August 1995, of the calciphile *Theodoxus fluviatilis* (L.) in the lower reaches of the River Nore (S61866 39035) a curious void in its distribution in south-east Ireland has been filled.

In mapping the Irish distribution of the species Lucey *et al.* (*J. Conch., Lond.* **34** (1991) p. 96) had noted that of the larger rivers in the south-east *Theodoxus* appeared conspicuous in its absence from the Nore, a calcium-rich river. The range in natural chemical characteristics of the site (Neill, *River Water Quality in Counties Carlow, Kilkenny, Tipperary, Waterford and Wexford and in the Borough of Waterford 1994*. Environmental Protection Agency, Kilkenny (1995) p. 168) viz. pH 8·2–8·6, alkalinity 171–261 (mg/l CaCO3) and hardness 197–310 (mg/l $CaCO_3$), would indicate moderately hard to hard-water conditions. The only other gastropods occurring at the site were the common species *Ancylus fluviatilis* Müll., *Potamopyrgus jenkinsi* (Smith) and *Lymnaea peregra* (Müll).

Whether this recording represents a new invasion by *T. fluviatilis* is unclear but it would be surprising if the species remained undetected since systematic river macroinvertebrate surveys began in 1971; this site, as well as 25 others along the river, had been sampled previously by the author on five occasions since 1981 and by his colleagues in the preceeding decade. It is possible that small populations have existed in the Nore prior to this recording though the probability is that it is a recent colonisation. *Theodoxus* had been found regularly in the lower reaches of the River Barrow during surveys and the Nore joins the estuary of that river some 13 km downstream from this site. *T. fluviatilis* can apparently tolerate a moderate degree of salinity with values of up to 17 per mille being reported (Nicol, *Proc. R. Soc. Edin.* **58** (1938) p. 182); the upper salinity value for measurements made at the confluence of the estuaries of the Barrow and Nore was 1·2 per mille during summer surveys (Lucey, *Draft Water Quality Management Plan for the Suir Barrow Nore Estuary. Volume 5, Water Quality*. An Foras Forbartha, Dublin (1985) p. 14). *Theodoxus* has been recorded at a location in south-east Ireland where the salinity ranged between 0·18 and 9·6 per mille (Lucey *et al. op. cit.* p. 96.) so the hypothesis that the extension in range to this new site was from the Barrow, via the brackish-water route, should not be excluded.

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J. Conch., Lond. **35:** 523–526 (1996)

BOOK REVIEWS

Check-list della Specie della Fauna Italiana. Minelli, A *et al.* published by "Edizioni Calderini" Via Emilia Levante, 31 – Bologna, Italy. 1995 ISBN-88-7019-966-5 Price L.15,000.

13 Caudofaveata, Solenogastres, Polyplacophora, Monoplacophora.
14 Gastropoda Prosobranchia, Heterobranchia Heterostropha.
15 Gastropoda Opisthobranchia, Divasibranchia, Gymnomorpha.
16 Gastropoda Pulmonata.
17 Bivalvia, Scaphopoda.
18 Cephalopoda.

This publication is one of a series of annotated check-lists covering the fauna of Italy, published under the auspices of the European Community in collaboration with Italian Ministry of Nature Conservation and the Italian Fauna Scientific Committee. Parts 13 to 18 inclusive cover the land, freshwater and marine mollusca of Italy.

This publication should help all those like me who have struggled over the years trying to make sense of the extensive molluscan fauna of Italy and its thousands of synonyms. However, like most publications of this type it also shows up the rate at which our knowledge of the molluscan fauna is expanding and, in some cases, contracting depending on lumpers or splitters. Having a specific interest in terrestrial slugs I checked the Pulmonate list produced by de Marco Bodon, Leonardo Favilli, Falco Giusti and Giuseppe Manganelli and found that the authors have listed 61 species. However, 4 of these, 3 *Limax* and 1 *Deroceras*, do not have specific names in the list. This appears, in some part, to be due to a conflict of opinion as to which of the several names available is correct. Several species names described by one or more of the above authors in recent years do not appear in the list. Several names found in previous check-lists are also missing. It would have helped if a much larger synonym had been available; it is difficult to establish if the missing names have been synonymised or not. I would also have found the volume much more useful if the various sub-genera had been included.

It was also interesting to note that three species currently included on the British list have been synchronised. *Arion sylvaticus* is included within *Arion circumscriptus*, *Cochlicopa lubricella* within *lubrica* and perhaps the most surprising of all, *Vallonia excentrica* is synonymised with *Vallonia pulchella*.

A good and fairly extensive bibliography is included with each section, as is a simple index. The various lists also indicate the distribution of the various species, divided into 5 sea areas, and 4 land areas, North & South Italy, Sardinia and Sicily.

The volume includes computer reference numbers for each genus and species, which suggests that some movement may be on the way towards a full computerized mapping scheme for Italy. If so, I look forward to seeing the results in due course.

Adrian Norris

The non-marine molluscs of the Maltese Islands. By F. Giusti, G. Manganelli and P. J. Schembri. Monografie XV, Museo Regionale di Scienze Naturali, Torino, 1995, pp 607, figs 635 (line drawings, half-tones and 8 in colour of habitats). ISBN 88–86401–24–1 (hard cover with dust jacket). Obtainable from Museo Regionale di Scienze Naturali, Via Giolitti, 36–10123, Torino, Italy. Price L. 130,000 + postage (payment on receipt of invoice; about £55).

This is a comprehensive monograph of a high standard, a pleasure to handle and to review. It is the result of a cooperative project between malacologists of the Dipartimento di Biologia Evolutiva of the University of Siena and biologists of the Department of Biology of the University of Msida, Malta, undertaken in the early 1980s. The aim of the project was to revise the taxonomic composition of the fossil and recent land and freshwater molluscan fauna of the Maltese Islands, to investigate its relationships with that of neighbouring area of Italy and North Africa, and to reconstruct its history. The work begins with a general description of the islands, their vegetation and non-marine fauna in general. Sections follow on the general organization and morphology of gastropods and bivalves, and a summary of the history of malacological research in the Maltese Islands. An identification key to species precedes the catalogue of species, which forms the bulk of the book (over 400 pages). Here, each of the 78 species recognised as valid (9 brackish, 13 freshwater, 56 terrestrial) is illustrated and described in detail, with the comprehensive information clearly set out in a standard arrangement of sections: synonymy, materials examined, identification and differential diagnosis, description (detailed accounts of the shell, genital system and radula), habitat, distribution, palaeontology in the Maltese Islands, general remarks, status and conservation. The book concludes with a brief review of doubtful species and uncertain identifications and a final chapter dealing mainly with biogeographical aspects and conservation. An appendix gives lists of species group taxa (fossil, recent and *nomina nuda*) based on molluscs of the Maltese Islands. There is an extensive list of references and index of taxa.

This is a most attractive book, of the highest quality in content, design and production. The style is clear and concise, yet pleasurable to read. I did not find a single typographical error. The limited number of species in the island fauna allows each one to be given sufficient space for a satisfyingly in-depth treatment, extending to about 6 pages for some species. The illustrations are an outstanding feature: 8 in colour of habitats, about 85 groups of half-tone figures of shells, (mostly full-page arrangements), and numerous line drawings of anatomy. The quality of both the photographs of the larger shells and the scanning electron micrographs of the smaller species is excellent and well matched by the standard of the reproduction. Many species are illustrated not only as whole shells but also fragments chosen to show internal plicae and lamellae.

The book is designed to serve as an identification guide and also to provide the scientific basis for future research. Six recent taxa are newly recorded for the Maltese Islands, including a new species of *Testacella*. Other recent taxa are new for these islands because they were previously reported under other names, and yet other names are revised. A number of new records are given of species found as Quaternary fossils.

Of great value in the catalogue of species is the text under the section 'Remarks', where often there is discussion of taxonomic and biogeographical questions affecting areas far greater than the Maltese Islands. As a freshwater specialist I particularly appreciated the extensive treatment of the Hydrobiidae; 26 pages dealing with just the 5 valid species recognised by the authors to occur in this island group, but considering many other taxa. Thanks to the expertise of Folco Giusti and Giuseppi Manganelli, this summary will greatly help the general reader to some understanding of the complex taxonomic questions concerning hydrobiid snails in the Mediterranean region.

Of the 78 species recognised, only 70 currently occur, or have until recently occurred in the Maltese Islands. Unfortunately 30 of these are considered to be under some form of threat (natural or man-made), which if continued might lead to further extinctions. There is some ground for hope that this faunal depletion may be slow or halted. Legislation passed by the Maltese Parliament in recent years encourages the authors to conclude that all the necessary legal and administrative mechanisms are in place for the conservation of threatened biota and habitats. 'All that remains to be done is to actually start putting this mechanism in motion'. This book is a fine example of what is needed to persuade administrators to take action to conserve wildlife – attractive illustrations of threatened organisms and clear information about the current status of populations and their vulnerability.

Congratulations to the authors, publisher and production team for their achievement. I strongly recommend this book and it is a bargain at the current sterling price. It will be indispensable to the researcher and serious collector and will give pleasure to everyone who is at all interested in non-marine molluscs.

David Brown

Origin and Evolutionary Radiation of the Mollusca, J. D. Taylor Ed., Centenary Symposium of the Malacological Society of London, Oxford University Press, 1996. ISBN 0 19 854980 6, i–ix, 1–392, price £75.00.

This volume consists of 31 papers presented as part of the Malacological Society of London's Centenary Symposium, with the same title as the book, held from 14–16 September 1993. The authors of the various contributions are the foremost experts in all the various fields of their profession – so this, together with its broad scope, makes the book an essential addition to the library of any institution or person seriously interested in Mollusca.

The contents are divided into three parts: origin of Mollusca and evolution of the major groups (10 papers), Gastropod evolution (17 papers), and evolution of scaphopods and bivalves (3 papers). In general the first part consists of new analyses, or fresh reviews, of already available data. This is not surprising because the papers cover so much ground that they could not be based solely on original observations. More new data is presented in the part on gastropods, less in the shortest final part. One new genus and species is described – *Ribeiria junior* Runnegar, 1996, early Middle Cambrian, Queensland (p. 85); the group names **Eogastropoda** (for Patellogastropoda plus possible ancestors) and **Orthogastropoda** (the rest of the gastropods) are introduced by Ponder and Lindberg (p. 145), and a revision of the systematics of the **Colloniidae** Cossmann, 1916 (Monaro, Conti and Szabo, pp. 200–202), includes a proposal for a new subfamily—**Adeorbisininae**.

John Taylor's claim in the Preface that "the chapters in this book represent an overview of current work on molluscan relationships and evolution . . ." is amply substantiated on reading. The contributions show that old established and new methods are being used, separately and, when appropriate, in combination to approach the problem of how gradually to reduce the unknown areas in the story of the origin and radiation of the Mollusca. A particularly welcome feature of the book is the wide variety of techniques and disciplines brought to bear on the subject – cladistics, palaeontology, anatomy including ultrastructure, developmental studies, DNA, rRNA and allozyme analyses and predation all feature.

Readers should not look for unanimity of conclusions but they will always find the reasons for the conclusions which are being advanced, or else a statement of why a result is inconclusive – and where needed an explanation of the methods used. The papers giving cladistics analyses in most cases list the characters used and give character matrices; this enables those interested to come to their own conclusions.

Production standards are generally excellent. There are very few typographical errors and minor nonsenses.

Where present, these appear to be due to oversights – especially where numbers or dimensions are involved. For instance, Wagner's statement (p. 162) 'This analysis includes 700 specimens representing over 350 valid species' does not seem to fit well with the statement further down the same paragraph that "Moderate degrees of intra specific variation were observed . . .", and there is a mismatch between the dimensions of 5–17 mm given for various Lepetid shell lengths (Angerer and Haszprunar, p. 173) and their earlier references to "7–10 mm thick sections" (p. 171) and eggs "up to 150 mm in diameter" (p. 173).

This books is especially recommended for purchase by all scientific institutions covering zoology, and by professional zoologists and palaeontologists. Others interested in Mollusca should not be deterred from purchasing it by the price.

David Long
1 August 1996

Bursidae of the World by Tiziano Cossigani, 1994. L'Informatore Piceno Ancona Italy. 118 pp. Hardback ISBN 88–86070–09–8 Price approx £33.

This beautifully illustrated work is described by its author as an Atlas which is just what it is. It does not claim to be a monographic treatment of the family Bursidae, although all the 64 species and subspecies known and considered valid by the authors are included. The text is in both English and Italian. The species are arranged systematically under genera with one to two pages devoted to each. Author and date are given together with an indication of size range, geographical distribution, location of type material when known, comparisons with similar species and a list of synonyms which is far from complete. The species descriptions are however so abbreviated as to be of little use. Under *Bursa angioyorum* for instance we are told 'This species differs from *B. muehlhaeusseri* by its larger size and some other important details'. What details? And under *Tutufa rubeta* 'It is very similar to *T. rubeta*!. The illustrations consist of high quality full colour photographs which are in every way excellent. Each species is shown in both ventral and dorsal views often with additional illustrations in the case of very variable ones, for example sixteen specimens of *Bursa rosa* and over forty for *B. granularis granularis*.

Unfortunately there are a large number of typographical errors and misprints which careful proof reading should have eliminated. Many of these become obvious when the text and indices are compared. For instance on p. 116 the following errors occur and this is by no means all on just one page! *Bursa awatii* Ray, 1849 should be 1949, *B. sonorana* Barry, 1960 should be Berry, *B. christinae* Part, 1989 should be Parth, *B. ponderosa* Reeve, 1842 should be 1844, *B. echinata* (Link, 1851) should be 1807, *B. luteostoma* Pease should be (Pease, 1861).

To complete the book there is a two page systematic arrangement of the family and a one page index of specific names indicating which are considered valid and which synonyms. This list is not cross-referenced to the main text and is far from comprehensive. The "Index", which is more a list of contents, is arranged in page order not alphabetically and is far from helpful! Finally there is a one page bibliography, largely confined to recent regional guides and a few articles covering the Bursidae in general. Some additional biological information concerning the animal, reproduction, feeding etc. would have been welcome. Likewise characteristics separating the different genera and subgenera all of which is entirely lacking. If a revised edition is ever contemplated it is to be hoped that the numerous errors in the text would be corrected. The superb illustrations would make this well worth while.

Tom Pain

Seashells of Eastern Arabia by Donald T. Bosch, S. Peter Dance, Robert G. Moolenbeek and P. Graham Oliver and edited by S. Peter Dance. 296 pp. Published by Motivate Publishing (1995) at £50.00 ISBN 1 873544 64 2.

This long awaited book, by a team of experts, is the most comprehensive guide to the shells of this region ever published, covering some 1273 species. Many of the species included are endemic to the region covered (The Persian Gulf & S. E. Arabian Peninsula) but others occur more widely making this book useful to anyone interested in Indian Ocean shells. Building on the work of the late Kathie Smythe, the extensive field work by the Bosch family – which has resulted in the discovery of many new species, the authors have spent several years preparing this work for publication. This extensive preparation ensures that this will be the authoritative guide to the region's shells for many years to come.

The book commences with a historical review of shell collecting in Eastern Arabia, a survey of factors influencing the molluscan fauna and a look at local habitats. This is followed by a systematic account of the species. Each species is described simply but clearly with details of habitat and distribution. Synonyms are not included unless well entrenched in the literature or of particular regional significance. The distribution given could be confusing in the absence of any other literature, since the range given is for the occurrence within the Eastern Arabian area only. For example for both *Harpa amouretta* and *Cypraea teulerei* Masirah Island is given as the range. This is fine for *C. teulerei*, which has been found living nowhere else but *H. amouretta* occurs from East Africa to Hawaii, North Australia to South Japan. The majority of species covered are illustrated in superb plates, most near life size, which show both dorsal and ventral views of gastropods and interior and exterior views of bivalves. For variable species multiple specimens are illustrated. Smaller species are well shown in photomicrographs and line drawings. It is, however, a pity that the photographs of some type specimens are not labelled as such – the holotype of *Lyria leslieboschae* for example.

The overall coverage of species is extremely good, especially for less well known families, and it is pleasing to find the marine pulmonates included. The coverage of turrids is limited to the larger species, however the authors acknowledge that "A comprehensive survey of Eastern Arabian turrids is beyond the scope of this book" and provide a reference to the most detailed survey available (of 1917). I am not sure of the identification of *Micromelo undatus* which is generally held to have an Atlantic distribution, and would suggest that this is the Indo-Pacific *M. guamensis*. Several shells are treated as new species "which will be described elsewhere", and a few are only assigned to generic level. Hopefully when these identifications are resolved a list of additional information will be published.

The systematic account is interspersed with short historical and ethnographical notes, which are both entertaining and informative, and is followed by a glossary, a good regional bibliography and the index. It is perhaps unfortunate that the index does not give references to genera although families are listed, so that for example Muricidae is included while *Chicoreus* is not.

To conclude, this book is highly recommended, it will be an essential reference for anyone studying marine shells from Eastern Arabia, and will be of great value in identifying shells from the wider Indian Ocean.

Kevin Brown

J. Conch., Lond. **35:** 527–534 (1996)

CONCHOLOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

REPORT OF THE COUNCIL 1995–1996

The Society announced with regret the deaths of two members, Mr R T Abbott, member since 1974 and Mr L Blaker, member since 1991.

Council Positions

In 1995 Dr Barry Colville was replaced as President by Dr Richard Preece, who stood down as Hon. Editor of the *Journal of Conchology*. Dr P. Graham Oliver was elected as Dr Preece's replacement on the *Journal*. Mr Paul Lee stood down as Hon. Editor of the *Conchologists' Newsletter*, and was replaced by Miss Rosemary Hill. New Ordinary Members of Council for 1995/6 were Mr Boyce, Mr Pinn and Mrs Street. Mr Palmer, Mr Brown and Miss Nelson began their second year on Council; Mr Philp, Mr Tracey and Dr Honnor began their final year on Council. In October 1995 Mr de Bartolomé retired as Trustee due to ill health and was replaced by Mr D C Long.

Publications

Council expresses its thanks to the two outgoing Editors, Dr Preece & Mr Lee, for their work. The Society published two issues of the *Journal of Conchology* (Volume 35, Parts 3 and 4). Four issues of the *Conchologists' Newsletter* were published (Volume 7, Part 3, Number 132, Volume 8, Part 1, Numbers 133–135). The Society also published the Annual Programme card for 1995 and in January 1996 produced an updated Membership List. The stock of Society publications was transferred from Leeds Museum to National Museum of Wales and in January 1996 a mail order form of Society publications and merchandise was produced.

Other Council Matters

During the past year the Society's Display Boards have been on show in Maidstone, Littlehampton, Hastings and Portsmouth Museums. They were also used as part of the Society stand at the Unitas Malacologica Congress in Vigo, Spain, where the Society sold merchandise to the value of £1,700 and recruited new members. As a result it was agreed in October that the CSGBI should become an Institutional Member of Unitas Malacologica. In April Ms Reynolds attended the Pacific Islands Land Snail Group (previously International *Partula* Propagation Group) meeting as Conchological Society delegates held at Jersey Wildlife Preservation Trust, having been awarded £100 towards her travelling expenses. The Society also agreed to donate £100 for two years in succession towards PILSG research. In January Ms Reynolds also attended the inaugural meeting of the TITAG Mollusc Sub Group in London. The Society gave its support to the new Channel Atlas project, Distribution of Marine Molluscs in the Channel (DOMMIC), which was instigated by Mrs Light (Hon. Marine Recorder) and is coordinated by Mr Killeen (Hon. Programme Secretary). The Society agreed to use the Research & Reserve Fund to create a Research Grant, and the rules of this were finalised in November 1995 and circulated to members in January 1996.

Ms Jane Reynolds
Hon. General Secretary

TREASURERS REPORT 1995 (SUBJECT TO AUDIT)

Expenditure exceeded income by £763.00 and the loss for the year, after transfer to the reserve fund and adjustments to the life members fund, was £165.00.

Income from subscription is £10,644 which is £2,594 less than the amount reported for 1994. The 1994 value includes £1,300 of 1995 subscription income received in 1994. For 1995 a more accurate accounting treatment has been used and 1996 subscriptions received at the end of 1995 will appear as income in the 1996 accounts.

Having allowed for this different treatment, 1995 has been similar to 1994. Income from subscriptions remains insufficient to cover the costs of producing and distributing the publications. Sales of back numbers of the publications have once again provided much needed income. This has been supplemented by the sale of publications donated by members and I would like to thank those who have made these donations. The costs of publishing and distributing the Society's publications was £12,708 which is not significantly different from 1994 (£11,981). The cost of producing and distributing the Journal has increased, but this has been offset by savings in the production costs of the Newsletter.

Sundry costs include the purchase of mugs and newsletter binders for resale.

The method of calculating the life membership reserve has been changed from one based on investment income to one based on the number of life members. The fund has been adjusted to £3220.00 for 1995 (28 life members at £115.00 each).

A transfer of £796.00 has been made to the Research & Reserve Fund following the principles used in past years.

At the end of the accounting year membership of the society stood at 366. This includes 36 institutes. Overall, 22 new members were recruited in 1995. This offset the loss resulting from resignations and lapsed subscriptions, giving a net increase of 1 member. This is a significant achievement as membership over the past few years has been in steady decline, with net losses of more than 20 members in each of the last two years.

In summary, the society continues to be in a reasonable financial position, though careful control of expenditure will be required to prevent the need for a substantial rise in the subscription.

MICHAEL WEIDELI
Treasurer

RECORDERS'S REPORT: NON-MARINE MOLLUSCA

The following new vice-comital records have been verified since the last Report (*J. Conch., Lond.* **35**, p. 387). Unless stated otherwise, all date from 1995.

Devon South (3): *Azeca goodalli*, Smallridge, Axminster (31/3000), D. E. Bolton & G. Musker.

Kent West (16): *Hygromia cinctella*, Dartford Heath (51/5173), R. C. Preece.

Surrey (17): *Limax valentianus*, Godalming (41/9644; garden), Jan Light.

Norfolk West (28): *Limax cinereoniger*, Great Wood, Swanton Novers (63/0130), M. E. A. Shardlow.

Chester (58): *Toltecia pusilla*, Brownlow Heath, Astbury (33/8359), S. J. McWilliam.

Cheviot (68): *Cecilioides acicula*, Bamburgh Castle (46/1835), Rosemary Hill, 1994.

Isle of Man (71): *Lymnaea auricularia*, Air Marsh (25/40), F. Balfour-Browne, 1910 (Stelfox Collection, Liverpool City Museums)

Perth Mid (88): *Vertigo geyeri*, Loch Tummel (27/86), B. Colville.
Perth East (89): *Vertigo genesii*, *Vertigo geyeri*, Blair Athol (27/96), B. Colville.
Ebudes North (104): *Lymnaea palustris*, Loch Cill Chriosd, Skye (18/6120), B. Colville.
Shetland (112): *Vallonia excentrica*, Bay of Scousborough (HU3618), R. Tallack.
Armagh (H37): *Physa gyrina*, Oxford Island, Lough Neagh (33/0462), R. Anderson.

The outstanding discoveries in an otherwise thin year have been Dr Colville's finds of the rare boreo-alpine snails *Vertigo genesii* and *Vertigo geyeri* living in Scotland. The former was previously known in the British Isles only from a single locus in Teesdale, and the latter from only a handful of sites, mostly in central Ireland but with outposts in Anglesey, Westmorland, and North Yorkshire. In Perthshire Dr Colville found *V. genesii* living at two places and *V. geyeri* at four, in calcareous flushes with a vegetation of low-growing sedges. In view of the fragility of the habitats the exact locations are witheld, only 10-km square references being given.

Limax cinereoniger, new to Norfolk, is an extremely rare slug in East Anglia. The habitat at Swanton Novers is ancient oak woodland.

Among introduced species, *Toltecia pusilla* has been discovered in Cheshire, a considerable northward extension of known range. Fresh shells were found in an open habitat under old railway sleepers. Another snail of gardens and waste ground, *Hygromia cinctella*, was seen in a gravel pit near Dartford; Kent thus joins the rapidly growing number of southern English counties harbouring this successful colonist of Mediterranean origin. The Mediterranean 'greenhouse slug' *Limax valentianus* has similarly appeared in a Surrey garden.

Among freshwater snails, *Physa gyrina* has been found in Lough Neagh. Introduced *Physa* are notoriously difficult to name on shell characters alone but Dr Anderson has proved the identity of the Irish form with North American *P. gyrina* by examining the genitalia. The species has previously been reliably reported from the British Isles only from two or three places in Glamorgan (Cardiff Canal, etc) and from the River Avon near Tewkesbury, but it is likely to be much more widespread. Dr Anderson has already shown that it is well established at several places along the southern and eastern shores of Lough Neagh.

M. P. KERNEY

RECORDER'S REPORT: MARINE MOLLUSCA MARCH 1996

During the year, the project to map the **D**istribution **o**f the **M**arine **M**olluscs **i**n the **C**hannel was officially launched under the acronym of **DOMMIC**. A poster was presented at the 12th International Malacological Congress held at Vigo, Spain under the auspices of Unitas Malacologica. The project is now being promoted by a small working group coordinated by Ian Killeen. Mapping of records is taking place by means of a purpose-programmed computer database. A field meeting based in Brittany is planned for July 1996 and promises scope for a large amount of new data for the project.

The focus for the Society's extended field trip in 1995 was Cornwall. With the cooperation of the Cornish Biological Records Centre 12 shores were recorded over a period of 5 days. Despite the diligent and continuous monitoring carried out over the years by CBRU we were able to add 8 species new to the Helford VMCA and a further 11 species were updated, of which 7 were formerly pre-1910. Of the new species records, most notable is that of *Leptochiton scabridus*. This was found in its characteristic habitat (*J. Conch. Lond.*, **34** (1992) p. 117) at 2 sites at the mouth of the Helford River. A more detailed report of the meeting will appear in *Conchologists' Newsletter*.

The year has seen a number of welcome submissions from loyal recorders as well as some new contributors. The nudibranch *Crimora papillata* Alder & Hancock was recorded by Roger Covey of SNH at Scapa Flow in Orkney. This rare species was hitherto recorded no further north than Galway Bay in Ireland.

Further to the first record of *Phaseolus guilonardi* Hoeksema in British Waters at Northumberland (*J. Conch. Lond.*, **35** (1994) p. 185), Ted Phorson has now found the species in shellsand from the Isle of Mull in May. This find, together with several others for extremely small and seldom-seen species, (*Tjaernoeia unisulcata*, *Arculus sykesi*) highlights the value of meticulous examination of shellsand as well as detailed shore recording and sublittoral benthic sampling.

Further to Phil Palmer's report of *Petricola lithophaga* from Sandwich Bay in Kent (*J. Conch. Lond.* **35** (1996) p. 378) a search for the species in the Chalk of Pegwell Bay might be able to establish whether the species is living in the area.

I would like to remind members that we are now keeping records for post-1990 data and nearly all records taken during collecting and surveying are likely to represent new data for the Marine Census. Even shores that have received regular attention by members of the Society through its field meetings over the years need to be re-evaluated. Can I therefore make a plea for a new burst of enthusiastic marine recording?

JANICE LIGHT

HON. PROGRAMME SECRETARY'S REPORT – MARCH 1996

The 1995 programme comprised seven indoor meetings held at the Natural History Museum in London, a visit to the British Antarctic Survey at Cambridge, eight field meetings and two workshops.

Lectures at indoor meetings were given by: Dave Clarke (London Zoo), Barry Colville, Ian Killeen, Bill Symondson (University of Wales, Cardiff), Robert Chandler (Riddlesdown High School, Croydon), Peter Tattersfield, and Chris Meacham (National Museum of Wales, Cardiff). The tour of the British Antarctic Survey in June was well attended and included illustrated lectures on the work and research of the Survey and tours to the aquaria, supply and equipment centres. This was followed by an afternoon visit to the University Museum of Zoology and the Sedgewick Museum in Cambridge. We are grateful to Lloyd Peck, Bernard Moran and the staff of BAS for providing us with an interesting and stimulating visit.

Field meetings, although less well attended than in previous years, continue to act as a focus for the Society's recording activities. Meetings were held at the following venues: Barton-on-Sea, Hants (leader Bill Pocock); Studland Bay, Dorset (leader Ian Killeen); Godalming, Surrey (leader Jan Light); Sawbridgeworth, Herts (leader Pryce Buckle); Southern Cornwall (leaders Jan Light and Stella Turk); Yorkshire Dales (leader David Lindley); Edgeworth, Gloucs (leader Helen Weideli) and East Leics (leader Jon Daws).

Two workshops were held in 1995. Following interest at the previous year's recording meeting Michael Weideli tutored a workshop introducing computerised mapping schemes and techniques. This event, held at Newbury Museum, was enthusiastically attended and gave members hands-on experience of the software available. The Society's eleventh molluscan workshop was again held at the home of Judith Nelson in Working.

The Society thanks all of the speakers at the above meetings and the organisers of the field meetings and workshops. I would like to take this opportunity of thanking all those people who have contributed to the Society's programmes during my nine years in office.

IAN KILLEEN

REPORT OF THE HON. CONSERVATION OFFICER

Key items from the 1995–96 year are summarised below.

The Biodiversity Challenge: an agenda for conservation in the U.K. (second edition)
(A) Following the launch of the challenge document in early 1995 the Department of the Environment commissioned the production of further work. This was completed thus:

1. three new Species Action Plans for the threatened freshwater species *Anisus vorticulus*, *Segmentina nitida* and *Pisidium tenuilineatum*
2. modified/standardised Species Action Plans for *Catinella arenaria*, *Margaritifera margaritifera*, *Myxas glutinosa*, *Pseudanodonta complanata*, *Vertigo angustior*, *V. geyeri*, *V. genesii*, *V. moulinsiana*.

(B) The Biodiversity Challenge Group requested information on the habitat requirements of 49 species of Mollusca of 'conservation concern'. A report was duly sent.

Special Areas of Conservation: The Society considered some of the sites proposed by the Government in Summer 1995. The main responses related to inappropriate site suggestions for *Vertigo moulinsiana* and concern at the omission of Portland Harbour and the Salcombe Estuary from the proposals. The Society also expressed concern at the inadequate initial consultation process re. S.A.C.s.

Wildlife & Countryside Act: Third Quinquennial Review of Schedules 5 & 8: The Society supported the removal of *Catinella arenaria*, the addition of *Atrina fragilis* (fan mussel) and increased protection for *Margaritifera margaritifera*. In addition, the Society has proposed the addition of *Anisus vorticulus* and *Segmentina nitida* to the Act amendments.

Portland Harbour Revision Order 1996: The Society made representations to the D.O.E. concerning the proposals for Portland Port Limited to take over the running of Portland Harbour. The Society is concerned to ensure that any change in harbour management pays due regard to the important marine and brackish water Mollusca resident in the harbour and the adjoining Fleet.

Advice and help: Has been given to a wide range of individuals and organisations. Some of these include:

- Pollution damage to cliffs near to the Clifton Suspension Bridge as a result of heavy metal contaminated grit used to remove paintwork from the bridge.
- Many requests for advice were dealt with concerning the Newbury Bypass route threatening communities of the rare snail, *Vertigo moulinsiana*. Additionally a full survey of the snail's presence on the road route was undertaken to provide objective advice to Friends of the Earth. A report was sent by F.O.E. to John Gummer.
- Representations were made to the Government concerning drastic grant reductions made to The Countryside Council for Wales.
- Detailed information and comment was provided to the R.S.P.B. for the forthcoming S.W. Regional Biodiversity Habitats and Species Audit Phase 1.

British Wildlife: The biannual molluscan wildlife report has continued to be produced for this journal.

Joint Committee for the Conservation for British Invertebrates: Membership of the Committee continues and has been valuable in providing contacts with other organisations. Three society members attended a Conservation Conference run by the JCCBI in February 1996.

Conservation work undertaken throughout the Society: Many other conservation activities have been undertaken by Society members throughout the year. These are too numerous to mention individually, but range from work with the *Partula* breeding programme to the launch of a Channel marine molluscan mapping project.

CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND
ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1995

Income and Expenditure Account

	31 Dec. 1995	31 Dec. 1994
	£	£
Assets		
Fees and Subscriptions	**10,644**	13,238
Investment Income	**2,523**	2,528
Sales & Donations	**2,794**	1,398
	15,961	17,164
Expenditure		
Publication Costs	**12,708**	11,981
Stationery & Sundry Postage	**1,251**	1,594
Meetings	**745**	906
Sundry Costs	**2,020**	1,534
	16,724	16,015
Excess of Income Over Expenditure	**(763)**	1,149
Transfer from Publicity Reserve	–	182
Transfer to Research & Reserve	**(796)**	(834)
Transfer to Life Membership	**1,394**	–
Profit/Loss for Year	**(165)**	497

CONCHOLOGICAL SOCIETY OF GREAT BRITAIN & IRELAND ACCOUNTS FOR THE YEAR ENDED 31 DECEMBER 1995

Balance Sheet

	31 Dec. 1995 £	31 Dec. 1994 £
Assets		
Investment at Cost	**15,172**	17,372
Cash	**25,771**	15,447
Debtors	**221**	1,508
	41,164	34,327
Liabilities		
Creditors and Accrued Charges	**6,570**	1,410
Advance Subscription	**2,344**	–
Life Members Fund	**3,220**	4,614
Reserve & Research Fund	**7,468**	6,672
Other Reserves	**96**	–
	19,698	12,696
Net Current Assets	**21,466**	21,631
Represented by:		
Capital Account brought fwd.	**21,631**	21,134
Profit/(Loss) for year	**(165)**	497
	21,466	21,631

M. D. WEIDELI
Honorary Treasurer

J. LIGHT

D. WORTH
Honorary Auditors

INSTRUCTIONS TO AUTHORS

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